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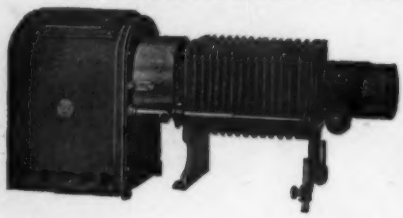

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SCHOOL SCIENCE AND MATHEMATICS

VOL. XIX, No. 5 MAY, 1919 WHOLE No. 160

THE OUTLOOK FOR GEOLOGY AND GEOGRAPHY.[1]

BY F. W. DE WOLF,

State Geological Survey, Urbana, Illinois.

1. EXPERIENCES OF THE WAR.

Before speaking of the outlook in geology and geography it will be worth while to consider briefly some applications of these sciences to war activities in the several armies.

The usefulness of geology and geography in the war is not generally realized. Indeed their possible use, either directly or indirectly, seemed unlikely to those in responsible charge of the American program, until the scientists themselves had by persistence shown that these earth sciences have many practical applications to warfare, and to those home industries necessary to sustain the army and the nation. However, the government accepted these professional services gradually; rapidly in some lines and slowly in others. The strenuous efforts made by groups and by individuals to bring this about would make a most interesting and entertaining story if it could be fully written. It is enough to say of the efforts, that they succeeded to a marked degree before active fighting stopped, and that geologists and geographers were giving increasing service with the following agencies: the field army, the military intelligence, the officer training camps, the war industries, war trade, and shipping boards, the fuel administration, and the House commission engaged in preparing for the peace conferences. Their work made a splendid impression, and a brief statement covering some of it will be enlightening.

Of first importance was the making of accurate topographic maps of large scale for control of artillery fire. About one hundred commissioned topographers from the U. S. Geological Survey were engaged in the work on the American lines, and in

[1]Read at the March meeting of the Illinois Academy of Science at Jacksonville.

cooperation with the French. A map-printing plant larger than the combined plants in Washington and capable of producing nearly 1,000,000 maps each month was erected and operated. Many of the maps were revised and reissued daily. As a result, all officers realize as never before the dependence of an army on topographic maps.

Related to map-making was the building of relief models. These revealed the visibility of the country from observation posts; and by the aid of special instruments assisted in controlling shell-fire on enemy targets. Finished models showing relief and villages and roads were made by the thousands, and in the remarkable time of a few hours for each mold.

Another vital need of the army was an enormous supply of water for men and horses, for concrete construction work, and for power plants and locomotives. Geologists made maps showing locations of springs and of shallow and deep water-bearing rocks. They also supervised the boring of wells, especially in the British army.

Supplies of rock, gravel, and sand were also needed in large amounts for building roads, gun foundations, dugouts, supply depots, and harbor works. Geologists assisted in locating these materials.

Finally, maps and diagrams were made of the rock formations along the lines held by our army, and by the enemy, in order to show their suitability for the construction of trenches, dugouts, and mines. It was possible to observe existing works, and then to predict the conditions in new areas which were geologically similar. Thus, it was possible to say in advance whether trenches would stand without revetment of the walls; whether they would be wet or dry during certain seasons; and to advise regarding tools which would be needed to construct defensive works. Maps were prepared to show the probable effect of artillery fire on the formations; thus, whether the rocks would shatter and add to the casualties; and whether barrage fire would make the ground impassable for tanks.

These various uses for geologists in direct warfare were developed by the allied armies in varying degrees, but the Germans had prepared a systematic organization in advance, or at an early date. Our geologists and geographers at home tried unsuccessfully in 1917 to have technical units organized for service at the front, and to introduce certain kinds of instruction in the officers'

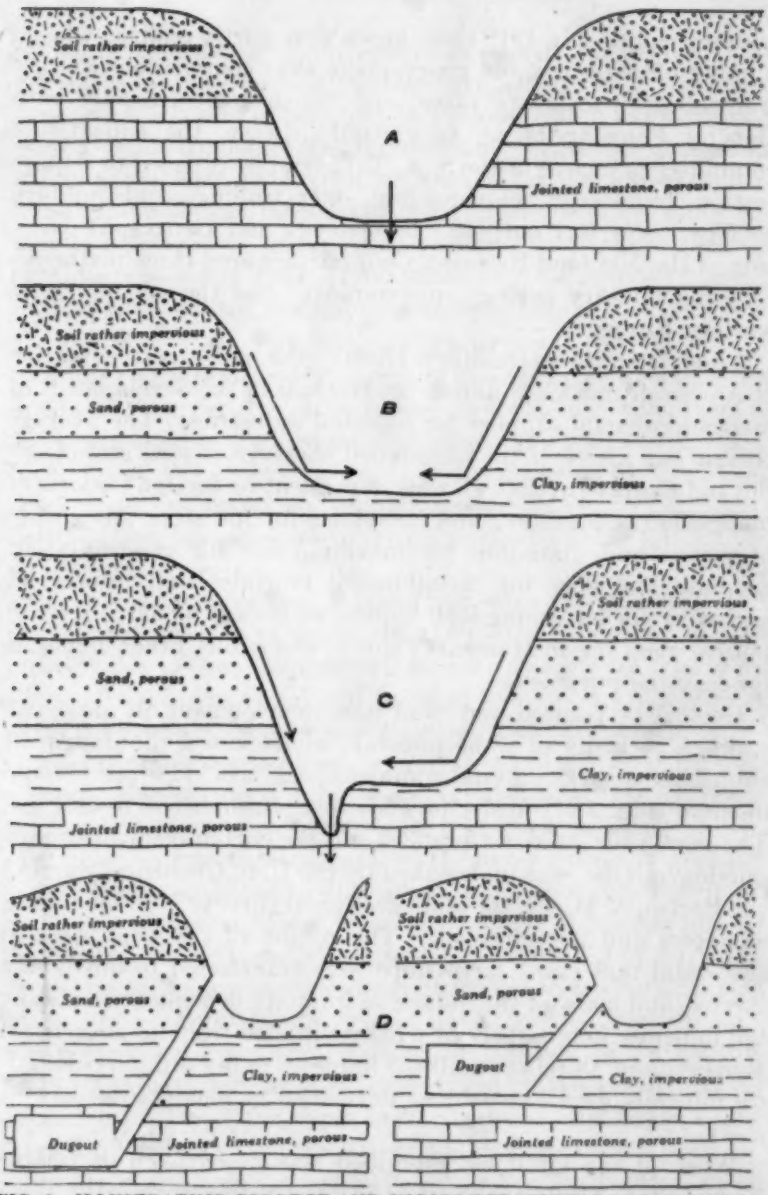


FIG. 1. ILLUSTRATING CORRECT AND INCORRECT METHODS OF LOCATING TRENCHES AND DUGOUTS.

A. Correct trench construction. Water escapes through the porous jointed limestone.

B. Incorrect trench construction. Water is held in trench by impervious clay.

C. Correct trench construction under same conditions as "B," when it is not feasible to sink the whole trench to the level of the porous limestone as in "A." A small drainage trench carries water down into the porous limestone, permitting its escape.

D. To the left, properly placed dugout. Drainage takes place readily through the limestone, making the dugout relatively dry. To the right, improperly placed dugout. Water fails to escape through the impervious clay and the dugout is subject to very poor drainage or even flooding.

training camps. In 1918 these hopes were partly realized when a number of geologists and geographers were commissioned in the war college intelligence office, and the geological service with General Pershing began to expand. Later, the educational committee in charge of the S. A. T. C. courses planned to require certain courses in map reading, map-making, and military geology. For this purpose, the Geology and Geography Division of the National Research Council prepared three textbooks covering military geology, meteorology, and the geography of western Europe.

Aside from these military efforts, the most active service of American geologists during the war was in the development of domestic mineral supplies for essential industries. The average citizen was aware of the threatened shortage of coal and of oil, but did not realize that we were dependent on foreign imports of manganese, chromium, and molybdenum for steel tempering; of pyrite and platinum for making acids for explosives; of graphite and clay for metallurgical crucibles and retorts; of antimony for hardening lead bullets; of potash for fertilizers; of optical glass for instruments; and of numerous other minerals for essential purposes.

Geologists pointed out that the development of domestic supplies of many of these minerals would lessen the danger of submarine attacks on vital commerce, and would permit the use of more ships for transfer of soldiers and munitions to Europe. The search for domestic supplies and the encouragement of production and use was undertaken by the U. S. Geological Survey, the Bureau of Mines, the state geological surveys, and by mining engineers and metallurgists. The results of the work were so successful that many large ships were transferred to direct war service, and many of the industries formerly dependent on imported minerals were largely or wholly supplied from home sources. Furthermore, to relieve railroad burdens, many ordinary domestic minerals were located and developed in new places close to market.

Work of the kind just described was undertaken in Illinois by the State Geological Survey in cooperation with other state and federal agencies. Fluorite for optical use was discovered, and sand for optical glass was investigated. The geologists and engineers demonstrated the practicability of recovering pyrite cheaply from our coal mines and made an estimate of possible output. Promising deposits of fire clay and ganister

for making refractory linings were examined and tested. The efforts of former years to locate new oil fields were continued, and new work was undertaken to prolong the producing life of our old fields by demonstrating methods of protecting oil sands from encroaching water. Other work of permanent as well as war-time value was the development of methods for using Illinois coal instead of transporting eastern coal and coke for the manufacture of city gas. These various special activities largely supplanted the usual work of the Geological Survey.

2. The Future Prospect.

Having now reviewed the work of geologists and geographers during the war period, can we foresee any further development or any change in the application of these sciences for the immediate future? As a colleague has said: "For two years we have been sharpening the sword and applying every effort to perfect its cutting edge," now we are to return to the field, the laboratory, and the classroom.

What lessons have been learned regarding the practical value of the earth sciences to the world, the nation, the state, and the individual? What improvements are possible in research? What of the larger social and political value of a knowledge of natural processes, world-geography and of world resources?

In answer, we have gained an added conviction of the fundamental value of topographic maps for defensive and offensive warfare; in the selection of routes for highways, railroads, electric power and communication lines; in the development of drainage and of water supplies; in the search for, and development of, minerals and other natural resources. The topographic map of the United States should be completed, not in 80 or 90 years, according to the former rate of progress, but in twelve or fifteen years. The map of Illinois should not proceed at the old rate, which promised completion in 1960, but should be finished by 1930. The cost will be more than saved to the tax payers by eliminating surveys for roads, water supplies, and other necessary developments throughout the entire State.

Similarly, geology has again demonstrated its practical value in locating water for domestic and industrial uses, and stone, gravel, and sand for building of roads, railroads, and other structures. A state like Illinois, about to invest $60,000,000 in the beginning of a hard-road system should first locate and investigate the materials which are available close to the selected routes. Furthermore, a state about to build a great waterway should

know the location and usefulness of the heavy, slow-moving mineral wealth in the adjacent territory which will help furnish profitable cargoes.

Again, we have seen in connection with minerals for war industries, the value of statistics of mineral production, of lists of producers, and of geological investigation of possible new sources of supply, in advance of acute need. Thus, in Illinois, we owe it to the nation, as well as ourselves, to collect accurate statistics, to complete an inventory of our enormous mineral wealth, and to encourage new or improved methods for its production, conservation, and wise utilization.

But while some of us, who needed no demonstration, have seen the justification of practical geography and geology, we have been dismayed to find, even in high places, that there was little, if any, advance appreciation of the military, industrial, and social significance of these sciences. They had been considered purely cultural and academic! No conception of their importance existed in the academies at West Point or Annapolis, in the intelligence service, or in the early organization of the boards for war industries, war trade, and fuel control. Representatives of the professions were repeatedly refused the chance to serve the country with their special talents, and finally gained the opportunity only by personal persistence, and in many cases without recognition of their profession. One cannot blame others for this condition, and I do not wish to criticize those who were doubtless following to the best of their ability the lines indicated by past education and experience. It is our fault that these subjects have almost disappeared from the high schools, and have never been so perfected as to be appreciated by engineers and by the general public.

Evidently the future problems of geology and geography include not only the better organization and pursuit of research, but the better dissemination of knowledge of the usefulness and significance of these sciences to every-day affairs. Our common schools and high schools should teach some of their required courses in terms of earth science. Our colleges and universities must develop *special* courses in geology and geography which will be recognized as *essential* to professional courses in civil, mining, chemical, and ceramic engineering, and to those in economics, sociology, and history. It will not be sufficient to teach only general courses and others adapted to students who are specializing in the earth sciences.

Similarly, in the routine work of official surveys and bureaus, an effort must be made to meet more of the needs of the mineral industries by cooperation with them, and by making known the results of investigations in common language rather than in the stereotyped form and professional lingo to which we have been accustomed. The maps presented should display more effectively and in more detail the character, usefulness, and distribution of the rock formations, while continuing to show also as formerly their relative ages and modes of origin. There should be more effective consultation and cooperation between state surveys and between state and federal surveys regarding development of purposes and methods, in order that official geology may be more practical than in the past, and also in order that fundamental problems of origin and correlation of the various formations and their enclosed minerals may be attacked on a national scale more vigorously than heretofore. Just as the experience of the war indicated the impracticability of centralizing all knowledge and all administrative power in Washington, and the consequent need for state councils, directors, and administrators, so strong official surveys and bureaus are required in both the national and the state governments, and their work should be better correlated and more cooperative than in the past.

In regard to pure research in the earth sciences, it seems probable that much talent and time has been wasted in the universities and other research institutions by lack of cooperation on a national and international scale. There has been too little knowledge of progress elsewhere, and of the relative value and timeliness of alternative problems to be undertaken. A most promising sign for the future lies in the proposed development of the National Research Council in this country, and of similar councils in many foreign countries. These councils will surely stimulate and systematize all scientific research, without improperly checking individual initiative and originality.

Following development along the lines which I have indicated, I trust the earth sciences will influence the United States and the whole world to a marked degree in the coming period. As a result of our participation in a foreign war for democratic ideals, and as a result of the world trade in which we shall engage, we must have a knowledge of foreign lands, their physical character, their resources, and their peoples, together with a better knowledge of our home country. A knowledge of human geography is to become of great importance to our whole population.

A SURVEY OF THE GENERAL SCIENCE SITUATION IN ILLINOIS. [1]

By C. F. Miller,
Superintendent of Schools, Normal, Ill.

The motive for this investigation originated from ideas advanced in regard to the reorganization of science education after it has been given the acid test of war.

It is very evident that science is to command larger recognition in our program of educational reconstruction. Our scientists and engineers compared favorably with those of other nations because we were exceedingly fortunate in having conditions in this country that made science and engineering attractive to college and high school students, not so much because of elementary exploratory courses of their abilities and aptitudes, but because of rewards offered in a rapidly growing country with great engineering and commercial projects. We are aware that time will in a measure eliminate some features that heretofore have been a source of attraction, and that preparatory courses must induct pupils into science courses. During this period of reconstruction the call for trained specialists will be more insistent than any previously known. Our leaders can clearly see that this nation's future depends largely on its standing as a scientific nation. This embodies the exploration of the child's abilities, proper direction, and an awakening of latent possibilities, bringing him into sympathetic appreciation with this new trend so necessary to the future development of the nation. School administrators are fully awakened to the demands and are groping for a panacea to solve their difficulties. The War Department's announcement of July 10 very clearly expresses the vital significance of emphasis on science teaching as it affects the training of officials in the S. A. T. C., as the following extract shows: "This is a war in which soldiers are not only marksmen, but also engineers, chemists, physicists, geologists, and specialists in many other lines—science training is indispensable." The Bureau of Education has recently made public the report of the Committee on Science Teaching in Secondary Schools, emphasizing expanded and radical changes in science teaching, from which I quote in part: "To encourage high school students to elect more work in science and at the same time to lay the foundation for a general appeal to science and its methods, every effort should be made to arouse a lively interest

[1] Read before the General Science Section of the Central Science and Mathematics Teachers Association, Chicago, Nov. 30, 1918.

in science, particularly in grades seven to nine." "Wherever practicable, certainly in grades seven to nine, in junior high schools, and the first year of four-year schools, the artificial separation of the sciences so that they are treated as separate subjects should be ignored for the greater end of interpreting the problems of daily life. In solving a problem appeal should be made to any science that will contribute to the problem in hand." It will require time and careful thought to realize this program. For the present, at least, the problem must remain as a standard by which we may check progress and towards which we may seek to approximate. I have discussed the present unsettled situation with many administrators in this and other states—always with the same results. The doctors cannot agree; the authors, judging from textbooks, cannot agree on even a general aim; the courses are not standardized; the advocates are not on common ground; the courses are not generally accredited; and the money, teachers, or facilities are lacking for a "trial and error" experiment.

The administrator has a different viewpoint from many agencies advocating general science—his board of education and patrons must be shown that the subject deserves and will maintain its place in the curriculum permanently. He admits that he is not satisfied with his beginning science courses, and demands that "the powers that be" get together and agree on certain aims and standards at once practicable as a basis for organization and accrediting.

As an ideal, justification or elimination of this new subject depends upon how safely we avoid the error of falling back into the textbook type of course, and how skilfully we make use of the newer types of teaching that are being developed. Yet according to the best available information, and being handicapped by the scarcity of properly trained teachers in the technique of presentation, most of us must admit that the textbook at the present time determines the content and organization of the majority of courses offered in this state. At the present time there are over thirty general science textbooks in use, with very few having a common basis. During this investigation I was surprised at the number of administrators whose only charge against general science was the textbook, and still further surprised that many were not just sure what they really desired for a textbook. In spite of the general feeling in certain sections general science is discredited by few, and there is a very enthu-

siastic demand. Because of unsettled conditions many have assumed the attitude of "watchful waiting." Administrators admit that they are simply marking time with what special science they inherited, or using the expensive "trial and error method" in an effort to satisfy local needs.

In several near-by states general science has made rapid strides, due somewhat, I believe, to its recognition by colleges of the state. Michigan leads with 138 schools teaching general science and lists 118 North Central Association schools. Iowa is next with 135 general science schools and 80 North Central schools. Wisconsin has 130 general science schools and 106 North Central schools. Illinois has 120 schools teaching general science, but the effect of 172 North Central schools not generally receiving credit for general science undoubtedly has checked the number of adoptions. And yet, upon investigating the attitude of the accrediting agencies, I do not find them adverse to recognizing general science. Their attitude is one of caution, anticipating each year to see something tangible in standardized form grow out of this controversy. I hope that this investigation will shed some light on the subject, because administrators are personally responsible for all of the data used as a basis of conclusions.

North Central Association schools were selected as being representative of the most progressive type of schools in Illinois because in most cases they are supervised by professionally trained educators who are students of new educational problems. A questionnaire was sent to every North Central Association school in the state, exclusive of the Chicago schools, and to a select few representing a special type of township community high schools rapidly being established in the state. No effort was made to reach schools teaching general science, and you will notice from the figures submitted that they average about 50-50. In all two hundred questionnaires were sent in the following form:

GENERAL SCIENCE QUESTIONNAIRE.

NOTE.—If answer to Question No. 1 is "No," skip to Question No. 9. If answer to No. 1 is "Yes," answer Questions No. 1-No. 9 and No. 12. ALL SHOULD VOTE ON THE AIMS OF GENERAL SCIENCE.

1. Does your school offer general science?.....
2. Required or elective? (Underline one.).....
3. In what grade or grades?.....
4. How long has it been taught in your school?.....
5. In your opinion is the course regarded favorably? (1) by teachers? ..... (2) by pupils?.....
6. Is there evidence that the course leads to further interest in science? .....

7. Is this indicated by more intelligent election of further science?

8. What criticisms do you have of general science as now taught?

9. Why is general science NOT offered in your school?

10. Provided its aims were clearly defined and acceptable and the course fully accredited, would you desire to add it to your curriculum?

11. Are you altogether satisfied with your ninth grade science?

12. If colleges and universities prepared teachers of general science, would it simplify your problem?

I was unfortunate in that the questionnaires were placed in the mail just as a state-wide quarantine was ordered, which undoubtedly delayed some replies which are coming too late to classify. You will note that the questionnaire is brief, arranged in this order, because it was to be answered by administrators personally, and I was convinced that they would not answer it unless this form was used to economize their time. At the time this paper was prepared 112 were returned, of which sixty schools were teaching general science and fifty-two schools were not. Let us first take for consideration the sixty schools now teaching general science. In twenty-six schools it is offered as elective, and in thirty-four schools it is required. The returns are rather definite as to the place of general science in the curricula, as fifty-seven offer it in the ninth grade and three in the eighth and ninth. In each case of the latter it is offered in the eighth grade the second semester, and the ninth the first semester. I found in some cases that where courses of nature study and elementary science were offered there is a growing inclination to require general science of all pupils who have been trained in and are graduates of the country district schools, while the graduates of the city schools who have had some elementary science are given the privilege of election in ninth-grade science.

It is apparent from the answers to the next question that general science should be properly defined, and that there is much variation of opinion as to just what such a course should include. Some seem to doubt the data that general science was really in existence, as such, over a period of time as long as some of the figures indicate. The length of time that general science has been taught in these schools varies as follows: one year, seven schools; two years, twelve; three years, fourteen; four years, eleven; five years, three; six years, two; ten years, one; fifteen years, one; sixteen years, two; twenty years, one; uncertain, six.

In reply to the question, "Is general science regarded favor-

ably? (1) by teachers? (2) by pupils? I am somewhat impressed by its popularity and felt need among teachers and pupils. In sixty schools, fifty-five teachers regard it favorably, three unfavorably, and two as questionable. The pupils of fifty-nine schools regarded it favorably and one unfavorably. In several instances this question was answered, "Very much so," indicating real enthusiasm. I presume there are those who will say that pupils fed on highly spiced "dessert and faddism" from the whole field of science would naturally be pleased. But they must remember that pure interest which originates in the child's environment will many times surmount great difficulties in learning. Just now we are seriously concerned with the special value of general science to those who drop out of school after completing the common pabulum of science. Dewey says in part, "We must remember that although in school we are always treating pupils as embryonic scientists who are interrupted and cut off before they get very far, the great mass of pupils will never be scientific specialists. The value of science for them resides in the added meaning it gives to the usual occurrences of their everyday surroundings and occupations. None the less, we want a high school which will tend to attract those who have distinct calling for specialized inquiry and one which prepares them to enter on it." "What we need is to hitch the horse of concrete experience with daily occupation and surroundings to a cart loaded with specialized scientific knowledge."

In order to verify the assertion that a course in general science is explanatory of the child's abilities and aptitudes, I asked the question, "Is there evidence that the course leads to further interest in science?" Forty-nine administrators answered "Yes," many giving the proof of the assertion, while six answered "No," and five had not taught it long enough to draw conclusions.

In reply to the next question forty-eight asserted that this was evident by an increase in the size of science classes, showing increased stimulus in science election, and five were uncertain for reasons mentioned above.

Throughout this investigation it was very evident to me that the time is here for administrators, college professors, specialists, and teachers to exchange ideas and come to some understanding regarding the elements of contention. At the high school conference at the University of Illinois recently, many administrators expressed approval of the action taken in the combined science meeting, where a resolution was passed, signed by leaders

of the various factions, who were willing to concede their "hobbies" in order to get unified action which has long delayed marked progress in this state. I think in view of this statement, that criticism coming from administrators with varying degrees of experience in dealing with general science in their schools will be of special interest to this group. These criticisms I have tried to group in the following statements because the ideas expressed by many were practically the same and are consequently grouped somewhat after the plan of a composition measuring scale.

Criticisms of General Science

1. A piecemeal mixture of science, still kept distinct.
2. Courses unbalanced, lack unity of organization.
3. Emphasis placed by the authors or teachers on special lines of enthusiasm.
4. Too difficult, not adapted to the age of the pupils.
5. Laboratory equipment not standardized.
6. Lack consciousness of a general aim.
7. Lack of properly prepared teachers make it a textbook science.
8. Teacher does not have the general science attitude. He thinks because of his special science training of each phase as a definitely segregated area, and classifies any subject matter under heads of special sciences before presentation.
9. It is simply a "trial and error" science.
10. General science teachers should be the most resourceful teachers in the faculty, and this type is difficult to find.
11. Is not accredited.

A brief consideration of the above criticisms will very clearly indicate that unified action on the part of the various agencies concerned will obviate the majority.

Considering the reasons fifty-two schools are not teaching general science, we find lack of teachers prevents ten from adopting it; thirty-five would adopt it if accredited; four expect to adopt it next semester or next year; and three have discontinued it for reasons mentioned above or because of a change in administrators not believing in the subject.

In reply to the question, "Provided its aims were clearly defined and acceptable and the course fully accredited, would you desire to add it to your curriculum?" forty-seven answered "Yes," and five "No." Five believe that the special science

commonly offered to the ninth-grade pupils is superior, but forty-seven are dissatisfied with their present science and are anxious for relief.

There seems to be a felt need for the special preparation of general science teachers in colleges and universities. From the 112 questionnaires, seven did not answer the question, six answered "No," and ninety-nine are convinced that it would simplify their problem. There is little doubt that general science will repeat the history of physical geography unless teachers are adequately prepared. How many general science teachers have taken at least a course at a good university in chemistry, physics, botany, zoology, physiography, bacteriology, astronomy, and mineralogy, all of which an adequately prepared teacher of general science should have because of the wide scope of the subject. This teacher should be extensively prepared in the sciences, versatile, enthusiastic, and most resourceful. Administrators demand this, and for the lack of it general science may not survive.

In practicing my previous assertion that we must "get together" and have at least a general aim in common, I have included C. M. Howe's aims in my questionnaire, and followed the same plan of tabulation as found in his article in the *General Science Quarterly* for May, 1918:

AIMS OF GENERAL SCIENCE.

Please number, in order of their relative importance to you, the commonly expressed aims of General Science. (Write 1 in front of most important, 2 in front of next. Please try to rank entire list as best you can.) Aims—General Science in the first years of high school should give each pupil:

(*a*) A fund of valuable information about nature and science.

(*b*) The greatest possible understanding, appreciation, and control of his every day environment.

(*c*) Preparation and foundation for the later study of special sciences.

(*d*) Appreciation of the applications of science in modern industrial and social life.

(*e*) Training in the use of scientific method in solving vital problems.

(*f*) A vocational survey of the sciences to guide and inspire plans for life work.

(*g*) Interest and motivation to vitalize his work and prevent his elimination.

(*h*) Appreciation of the unity and beauty of science and of the work of its master minds.

(*i*) Training in cold, scientific thinking, carried on with strict self-elimination. (Coulter.)

Aim of General Science—As Ranked by Eighty Science Teachers.

Adapted from C. M. Howe.

Rank		1	2	3	4	5	6	7	8	9	Total
1	(*b*)	53	10	7	2	4	3	00	00	1	149
2	(*d*)	5	23	15	17	11	2	5	2	00	282
3	(*a*)	12	13	13	17	10	7	4	3	1	293
4	(*e*)	8	11	12	14	7	7	11	9	1	357
5	(*c*)	6	6	10	11	14	8	12	11	2	400

6	(g)	1	10	12	9	10	15	13	8	2	406
7	(f)	1	7	9	8	17	16	13	6	3	421
8	(h)	1	2	5	5	10	16	11	27	3	506
9	(i)	1	3	5	4	3	2	4	6	52	609
		1	2	3	4	5	6	7	8	9	Total

Aim of General Science—As Ranked by Eighty-one Illinois Administrators.

Rank										
1	(b)	38	13	14	7	4	4	2	00	00	192
2	(d)	5	29	21	9	8	8	1	00	00	257
3	(a)	18	16	16	12	9	3	1	4	2	266
4	(c)	11	9	10	13	19	12	5	2	00	323
5	(e)	4	4	5	15	14	11	24	2	2	425
6	(g)	3	4	8	12	12	23	12	8	00	429
7	(f)	1	5	4	11	10	18	24	8	00	457
8	(h)	1	1	3	2	2	1	9	49	13	609
9	(i)	00	00	00	00	3	2	3	8	64	688

Peculiarly in the number of questionnaires tabulated, we were fortunate to have practically the same number. Mr. Howe tabulated eighty and I tabulated eighty-one. This gives us an opportunity to make a comparison of the composite judgments of science teachers of actual experience with that of administrators, the majority of whom offer general science in their schools. The tables give the final ranking and frequencies. The total score is secured by multiplying the frequency by the rank, and adding the products. I have followed this plan because it makes more convenient a comparison of results. Careful study of the tables shows conclusions almost identical. The aim, "Understanding, appreciation, and control of his everyday environment" is placed first. Second, "Appreciation of applications of science in industrial and social life." Third, "A fund of valuable information about nature and science." These rankings for the first three aims are identical with those of Mr. Howe, but after the first three there is some variation. This is not of any great consequence as agreement extends far enough down the scale so that it leaves room for little controversy. In view of the agreement on aims between people so vitally concerned in the general science question, it seems evident that some agreement could be reached on content that would at least show progress, or perhaps an agreement on projects would offer promise of desirable results. The latter, however, is far from being developed to a point where most teachers can make much use of this idea.

I am convinced that extended controversy and disagreement will only serve to complicate the situation. At present many schools in Illinois are planning to qualify under the Smith-Hughes Bill. The interpretation of this bill by state inspectors is such

that it demands segregation of boys and girls in science classes largely because of the natural division in training for vocations. I am sure that the people who are planning such courses to include general science are soliciting a definite recommendation for organization of the science with general aims adaptable to such courses. Electing to come under the provisions of this bill will lead to a type of general science for boys that will deal with problems closely related to vocations for boys and at the same time give them an understanding, appreciation, and control of their everyday environment. Girls will be given special courses correlated with their vocational courses. More schools because of this work have during the past year required general science in only certain courses and have left few subjects for election in the ninth grade. I can foresee that different texts and plans of instruction will be used in the same school, a type for boys, a type for girls, and a special exploratory course leading on to college courses with a view to training those for specialists who have natural ability in that direction.

Finally, I believe, enough pioneering has been done in Illinois to offer sufficient data that will warrant a unified effort to suggest a practicable working basis of organization around definite aims that will before any great time lead to a solution of our ninth-grade science problem.

CLASSROOM SAYINGS.

1. Latent heat is heat that is left over.
2. Friction is the movement of something without the power to lessen it.
3. Energy of our bodies is traced back to horse power.
4. A moment of force is a watt.
5. Ozone is obtained by subjecting oxygen to electrical shocks.
6. How would the world be changed if there was no nitrogen?

War would never come to pass,
And we wouldn't need to fear
That our friends and relatives
Had lost an eye or ear.

Gasoline accidents would be no more,
And explosions would be very rare,
And last of all we would have to breathe less,
For there wouldn't be so much "air."

7. Tin is abstracted from its ores by heating with coke.
8. White lead is a fine alloy for a paint.
9. Focal length of a lens is the point at which the distance between the distant object and the lens is brought to a focus.
10. Succulent roots are roots that stick to the walls by suction.
11. Inertia is the state in which all inanimate objects stand and sometimes in which all animate objects stand.

CONSTRUCTION WORK IN SOLID GEOMETRY.[1]

By EDWIN W. SCHREIBER

Proviso Township High School, Maywood, Illinois.

"To measure is to know." Thus spoke the great Kepler some three hundred years ago. I shall take his words as my text and shall endeavor in the brief time allotted me to discuss the effect those words have had upon my method of conducting construction work in my solid geometry classes.

In the eventful year of 1914, I joined the mathematics staff of the high school in New Castle, Pennsylvania, as commanding officer. My first campaign led me into the fields of Euclid, directing a company of so-called "flunkers" in second semester geometry. The morale of such a company, as might be expected, was at the breaking point. Regulation drill work as outlined by the textbook writers on geometry was out of the question. I must seek a new method of attack. For a while, I must confess, I was at a loss how to command the company. One day as I was reading a book on geometry I saw the words of Kepler, "To measure is to know." Surely there is truth in this statement I thought to myself and the words kept ringing in my ears, as they still do. It was not long before I was asking myself the question: "Does it mean that if I give my students more measuring work in geometry they will know more geometry?" I tried it out and found my new method of attack.

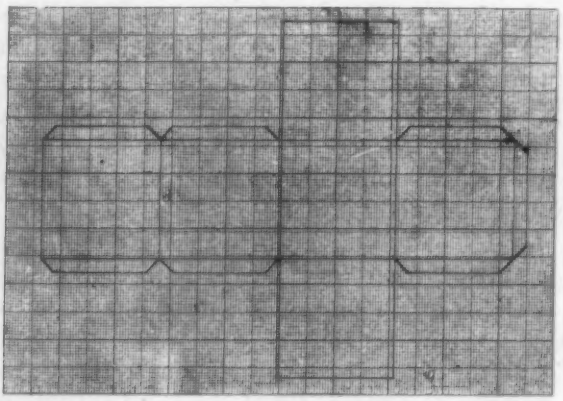
Every day I required my class to measure some geometrical magnitude. At one time they were sent to the blackboard and required to construct a square of 16.5 inches on a side, not simply to construct a square; at another, they were asked to determine the area of all the blackboards in the room to the nearest square inch. It was not long before I had some real enthusiasm in this "flunkers" class. Near the close of the course the spirit ran high and when the last recitation was over a goodly number of the class came to me personally and said that they had not only enjoyed the course but had really pursued it with understanding. More than twenty-five per cent of the class continued in their geometrical studies by taking the course in solid geometry, an elective subject, which I accepted as additional proof of the sincerity of their remarks. Measuring magnitudes, drawing to scale and to specifications in plane geometry convinced me that Kepler's words were true. No sooner proved in plane ge-

[1]Presented before the Mathematics Section of the Annual High School Conference, University of Illinois, Nov. 22, 1918.

ometry, I applied the same methods in solid geometry with the same results, and thus you have the historic introduction of the construction work that is to follow.

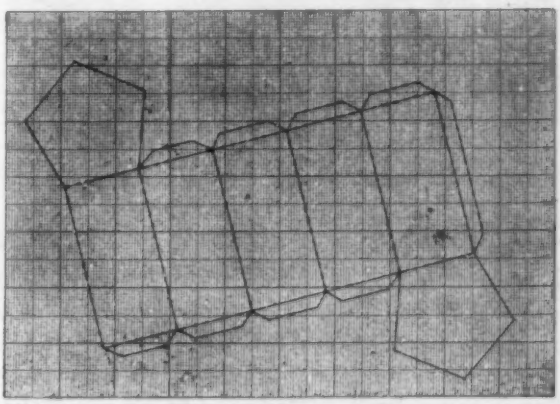
It has been my experience in the past that one of the benefits to be derived from a High School Conference of this nature is to hear someone relate definite classroom methods in a particular part or branch of a subject. Such will be my procedure.

The first part of the course in solid geometry, usually designated as Book VI, deals with lines and planes in space and offers little opportunity for interesting construction work. I require only one model in this division of the subject, namely a model to illustrate the theorem: If a line is perpendicular to each of two other lines at their point of intersection it is perpendicular to the plane of the two lines. This model is made according to specifications, insuring uniformity, and I make a freehand sketch on the board to show the class just how I want it made.



Though the remaining exercises deal entirely with polyhedrons I do not wait until I reach Book VII in the textbook before I begin operations in constructing some of the simpler polyhedrons. Two reasons may be given for so doing. (1) The work in polyhedrons offers excellent opportunity for the use of algebra and the sooner you can show the student where he can use his algebra as a tool the more interest he will take in the entire course. (2) I require each pupil to make ten models, one per week, and as ten weeks cannot be given to the study of polyhedrons if you would cover satisfactorily the subject of solid geometry as ordinarily outlined in the average textbook there must be an overlapping and I have found it better to do so in the beginning of the course than at the end.

Exercise No. 1 (as you have it before you)[2] reads: Required to construct a cube whose volume is ten cubic inches. To determine the length of the edge of the cube requires the solution of the equation $e^3 = 10$. Solving for e we obtain $e = \sqrt[3]{10}$ or 2.154, approximately. The approximate answer raises the question as to how the student is to extract the cube root of ten. Personally, if my class is not familiar with the use of logarithms I spend one or two recitations in explaining their use and you would be surprised how quickly this powerful computing tool is successfully operated by the average pupil. He does not need to know all about logarithms to be able to use logarithms. If he has access to a table of the powers and roots of numbers (which table ought to be in every high school textbook in mathematics, as well as a table of logarithms) he may use it to find the value of $\sqrt[3]{10}$. I require the approximate result to three places of decimals so that the nearest hundredth of an inch in the length of the edge is determined.

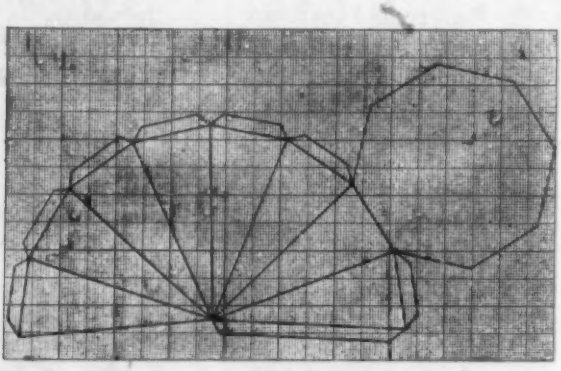


Next I impress upon the class the fact that they must draw to scale with greater accuracy than they have been accustomed to, the error allowed being one-hundredth of an inch. To insure such accuracy the diagrams are drawn upon a good quality of cross section paper (Eugene Dietzgen Co. No. 350). This is a tracing paper and therefore allows blue-prints to be made from the original diagram, a feature which I strongly recommend because of its duplicating powers. If an especially good diagram is submitted by a pupil the instructor can make several copies of the same for purposes of instruction or exhibition. Then, too, I find the easiest way to check up a diagram of some member of the class is to superimpose my own drawing upon that of the pupil

[2]See end of article.

and if both coincide throughout I accept the pupil's drawing. This method is possible because the paper is semi-transparent.

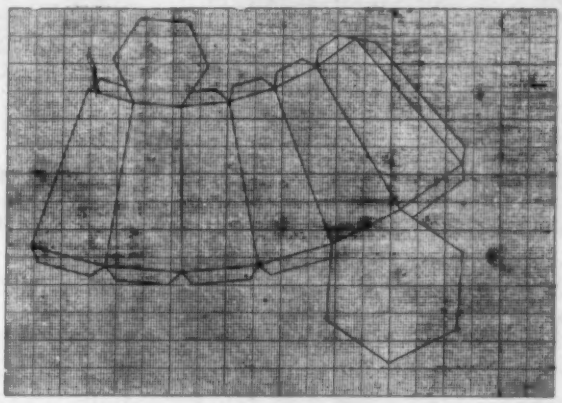
After the diagram has been presented and approved the pupil uses it as his pattern and the real construction of the cube is begun. It is made out of a good drawing paper (Eugene Dietzgen Co. No. 5 "Napoleon"). The pattern is placed upon the blank drawing paper and by means of a well sharpened pencil (4 or 6H) the necessary points are transferred by a slight downward pressure. The points are then joined by the required lines and thus the entire diagram is transferred. Perhaps you are wondering why I insisted upon a good diagram on the cross section paper, only to be transferred to the drawing paper. The reason is simple.



If the first model presented is not accepted, which is often the case with beginners, the time and effort required to make the original drawing is not lost. It is only a matter of using the pattern a second time. With the aid of a pair of scissors the diagram is cut out along the boundary lines and where folding along a line is necessary a knife is used to make a shallow cut. It has been my experience that the use of flaps in joining two edges together is better and makes a neater model than the use of gummed paper. Either glue or library paste may be employed as an adhesive but I find that the paste has a tendency to dry out in time and the model comes apart. The cube is now complete and if satisfactory is accepted and the pupil assigned a new construction exercise. Thus you have the "life-history" of a model cube.

Of the thirty exercises that I have designed for this construction work in solid geometry, you have fifteen before you and you may judge for yourselves the type of mental effort required

for their solution. It is plain to be seen that some are more difficult than others and naturally I give the former to the better students. In a few instances the determination of the formula for solving the unknown edge is so complex that I give the pupil the formula, but he still solves the approximate answer himself. I have in mind Ex. 21: Required to construct a regular icosahedron whose volume is ten cubic inches. In this exercise I give the formula, $V = 5e^3/12\ (\sqrt{5}+3)$ from which the approximate result for e is obtained when $V = 10$. Occasionally I have in my class a pupil who has studied trigonometry or who is taking it along with his solid geometry and in that case I ask him to find his own formula, and it is indeed gratifying to see the light of success in the eye of the young computer when he exclaims, like Archimedes of old, "Eureka!" (I have found it!). I sometimes think that we make our courses in mathematics too cut and dried, not giving sufficient opportunity for the exceptional pupil to cut his own path into the beautiful field of number relations.



After each member of the class has constructed eight exercises out of the thirty he is asked to design and construct two original models, working out any ideas he may have or be interested in. The results obtained are, in my opinion, very profitable, for it allows the student to express himself mathematically, to use his own mathematical wings, as it were. It is amazing what wonderful concoctions are fabricated and what gifts are laid upon the altar of exact thinking.

In conclusion let me summarize some of the values to be realized from the course of construction exercises as outlined above. (1) In the first place the class really enjoys building mathematical models. It ministers to the building instinct found in every

normal boy and girl. As the little child delights in making houses out of blocks so the larger child finds pleasure in giving tangible form to his ideas. When once you have your pupil liking his subject you have given him a decided impetus toward progress in it.

(2) The value of fixing the meaning of geometrical terms cannot be overestimated. I firmly believe that a student definitely knows what a truncated right triangular prism is after he has made one and that he will retain that knowledge for a greater length of time. Furthermore, he receives a training in exact measurement and constructs according to specifications, lessons he will not soon forget.

FIGURE 1. Three hundred models made by pupils at the New Castle High School. On the long strip of white paper in the background is written Shanks' value of π, to 707 decimal places. The strip is nearly seven feet long.

(3) All models have a volume of ten cubic inches, making them equivalent solids. This offers an excellent opportunity to train the mind in space relations. I find that my students have a much better conception of size and volume, of three dimensions, if you please, which is a most important conception in the study of solid geometry.

(4) We are beginning to appreciate the problem of individual differences in classroom instruction. Here is ample room to apply this new idea in pedagogy. In assigning the various exercises you can give the good student the more difficult models and the slow plodder the easier ones. Both types are kept busy and up to their ability.

Lest in my enthusiasm I have caused you to believe that I have substituted for the logic of Euclid a course in model con-

struction, let me emphatically state that such is not the case. A rough estimate of the time consumed in the work as outlined would place it at from fifteen to twenty per cent of the time of the entire course in solid geometry.

If I have given you food for thought my mission is fulfilled. But before I leave you I want to give tribute where tribute is due. How far that "candle throws his beams!" The candle is Kepler, and the beam, "to measure is to know."

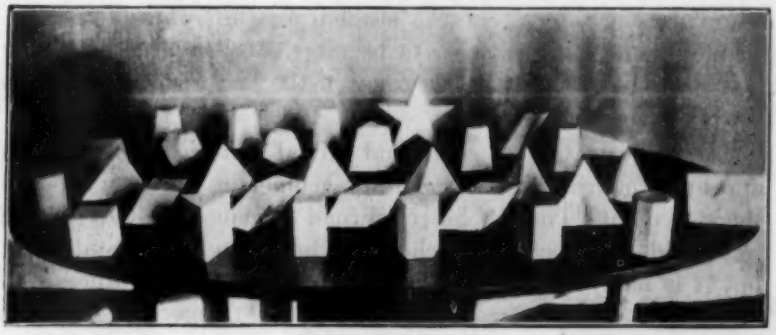


FIGURE 2. The thirty models made by pupils at the Proviso Township High School.

CONSTRUCTION EXERCISES IN SOLID GEOMETRY.

1. Required to construct a cube whose volume is ten cubic inches.
2. Required to construct a right prism whose base is an equilateral triangle, altitude three inches, and volume ten cubic inches.
4. Required to construct a right prism whose base is a regular pentagon, altitude three inches, and volume ten cubic inches.
7. Required to construct a right circular cylinder whose altitude is three inches and volume ten cubic inches.
11. Required to construct a parallelopiped oblique in three directions all of whose faces are congruent polygons, volume ten cubic inches, and all of whose face angles at a trihedral angle are sixty degrees.
12. Required to construct a regular tetrahedron whose volume is ten cubic inches.
14. Required to construct a regular quadrangular pyramid whose altitude is three inches and volume ten cubic inches.
17. Required to construct a regular octagonal pyramid whose altitude is three inches and volume ten cubic inches.
19. Required to construct a regular octahedron whose volume is ten cubic inches.
20. Required to construct a regular dodecahedron whose volume is ten cubic inches.
21. Required to construct a regular icosahedron whose volume is ten cubic inches.
25. Required to construct a frustum of a regular hexagonal pryamid whose volume is ten cubic inches, area of upper base two square inches, area of lower base five square inches.
27. Required to construct a frustum of a right circular cone whose volume is ten cubic inches, area of upper base two square inches, area of lower base, five square inches.
29. Required to construct an oblique prism whose base is a regular hexagon, altitude three inches, volume ten cubic inches, and one of whose dihedral angles between the base and a lateral face is sixty degrees.
30. Required to construct a truncated right triangular prism whose lateral edges are one, two, and three inches, respectively, whose base is an equilateral triangle, and whose volume is ten cubic inches.

HISTORICAL NOTES IN THE MATHEMATICAL TEXTBOOKS.

By G. A. MILLER,
University of Illinois.

On comparing the mathematical textbooks which appeared during the last two or three decades with those published earlier one cannot fail to notice a rapid increase in the number of historical notes. The main object of these notes does not usually seem to be to convey important historical information but to stimulate the interest of the student in the subjects treated. In fact, some authors seem to be more interested in providing this stimulus than in the accuracy of the historical information conveyed by such notes.

As an illustration of somewhat trivial historical notes which appear in many of our elementary geometries we may refer to the statement "There is no royal road to geometry," attributed to Euclid by Proclus. Euclid may have made this statement but it is likely that it was made before his day by others. In fact, an equivalent remark is attributed to an earlier Greek geometer, Menaechmus, who is said to have been asked by Alexander to teach him geometry *concisely*, and to have replied: "O king, through the country there are royal roads and roads for common citizens, but in geometry there is one road for all."

It would be desirable to know why this particular statement has become so popular as a historical note in the elementary geometries. The idea which it conveys is not peculiar to mathematics since there is no royal road to abstract knowledge in general, and geometry is intrinsically the least abstract among the broad mathematical subjects, but its elements are commonly studied in the most abstract manner. It appears not unlikely that the popularity of the statement mentioned above is largely due to the desire of the teacher to have some artificial stimulus to counteract the unnecessarily abstract approach to the subject of geometry and hence this popularity may be regarded as an implicit condemnation of the usual method of approach.

The fact that the historical notes in our textbook should lay a solid foundation for the study of the history of mathematics, provided this can be done without diminishing their stimulating value as regards the particular subjects treated, is in accord with general principles of education. This fact naturally raises the question, What are the most important elements of such a foundation? While it would be difficult to secure general agree-

ment as regards the twenty-five most important elements of the history of mathematics, and their arrangement in order of importance, it seems likely that there would not be much difference of opinion as regards the relative importance of a few of these elements.

In particular, probably nearly all mathematicians would agree that Euclid's *Elements* occupy the foremost place among the records upon which the history of elementary mathematics is based, and some of them might agree with the following statement relating to this work: "Since ancient times the *Elements* of Euclid have been accepted without protest as the foundation of mathematical science and have represented both the concept and the extent of elementary mathematics."[1]

In view of the preeminent position of Euclid's *Elements* in the history of elementary mathematics it is clear that the numerous references to this work in the elementary textbooks are justifiable. Unfortunately some of these references are misleading in various particulars. For instance, some writers refer to these *Elements* as containing *all* that was known about geometry in the days of Euclid.[2] To see that this is far from the truth it is only necessary to recall that the only curved line treated in them is the circle, while earlier Greek geometers had studied other curves. In particular, conic sections had been studied earlier and Euclid himself is believed to have written a work on this subject.

Another incorrect inference to which some of these historical notes give rise is that the *Elements* of Euclid were confined to geometry. In fact, some authors refer to them under the title *Elements of Geometry*. On the contrary, a considerable portion of this work is devoted to theoretical arithmetic, or the theory of numbers, and the entire work seems to have been intended to be an exposition of the elements of *pure* mathematics. As formal Algebra had not then been developed the *Elements* of Euclid fail to present this side of elementary mathematics in its modern form and hence they fail to exhibit clearly some of the most general methods in the field of elementary mathematics.

It was noted above that there would probably be little, if any, difference of opinion as regards the selection of the most important document relating to the history of elementary mathematics.

[1] Vom Altertum an haben die Elemente Euclids unbestritten als Grundlage der mathematischen Wissenschaft gegolten und sowohl Begriff als Umfang der Elementar mathematik bezeichnet. *Encyklopadie der Mathematischen Wissenschaften*, vol. 3, p. 773.

[2] As a recent illustration we may cite the statement on page 2 of *Plane Geometry* by Slaught and Lennes, 1918.

The selection of the document which might be regarded as next to Euclid's *Elements* among the fundamental records relating to this history would probably give rise to a greater diversity of opinions, although the work of Ahmes might reasonably be expected to receive the strongest support. Possibly the *arithmetica* of Diophantus should be regarded third in order of importance among the original sources for the history of elementary mathematics since it is preeminent among Greek works along algebraic lines.

Fortunately two of these three fundamental sources for the history of elementary mathematics are easily accessible to those who read only the English language. The *Elements* of Euclid are provided with a large number of historical and explanatory notes in the three volumes which appeared in 1908 under the title *The Thirteen Books of Euclid's Elements* by T. L. Heath, and two years later there appeared a second edition of *Diophantus of Alexandria, a study in the history of Greek Algebra*, by the same author, which includes a translation of the *arithmetica*.

On the other hand, the work of Ahmes has not yet been made so easily accessible to English readers. The articles by F. L. Griffith which appeared in the *Proceedings of the Society of Biblical Archaeology*, volumes 13 and 16, (1891 and 1894) are very useful, and R. C. Archibald published a helpful note on this work in the *American Mathematical Monthly*, volume 25 (1918), page 36. Hence those who use only the English language can readily secure a fair notion also of this important document bearing on the history of elementary mathematics.

The main objects of the present article are to emphasize the need of greater seriousness as regards the historical notes in our textbooks on elementary mathematics and to point out how improvements may easily be made. Some authors seem to regard these notes as a kind of playground for the imagination, providing even pictures which are supposed to represent ancient mathematicians about whose personal appearance we possess absolutely no reliable information. The trouble about such supposed historical data is that they hinder more than help the student who may later desire to make progress along the line of mathematical history, and it is questionable whether they are intrinsically more interesting than realities in the early history of our subject. At any rate, the latter may become the starting points of scholarly attainments and of increasing intellectual pleasure, while the former necessarily cannot lead further.

GRAPHICAL ALGEBRA.

By FRANCIS E. NIPHER,

Washington University, St. Louis, Mo.

For more than forty years, students and instructors in the physics department of Washington University have not hesitated to lay off the square or the cube of any determined value as a straight line. If the varied lengths and time of vibration of a simple pendulum are plotted, and a curve is obtained which resembles the familiar parabola, the lines representing the various values t are elongated until their length is t^2. If the result is a straight line, it gives conclusive evidence that $l = ct^2$.

A similar method may be used in representing graphically the value of $(y+x)^n$, where n, y and x may have any values. If we assume $n=6$, this quantity may be written $(y+x)^3\,(y+x)^3$. In the adjoining diagram y was assumed to be 3 units and x 2 units. The values of the terms of the expanded binomials $(y+x)^3$ are laid off along the two axes. The terms $3y^2x$ and $3yx^2$ are each

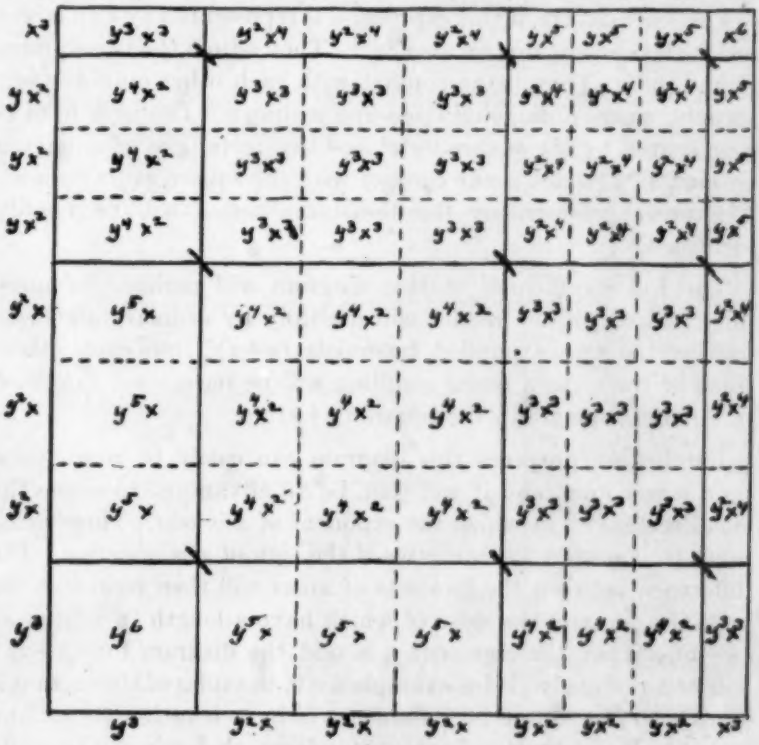


Diagram $(y+x)^6$.

separated into three lengths which are respectively y^2x and yx^2. Cross-lines were then drawn through the square whose sides had a length $x^3+3y^2x+3yx^2+x^3$, dividing it by means of full lines into 16 rectangular areas, and by additional dotted lines into 64 areas.

At the bottom of the diagram are eight rectangles. They represent the product of y^3 on the vertical axis with the terms laid off on the horizontal axis. The sum of these areas is $y^6+3y^5x+3y^4x^2+y^3x^3$. When the next term along the vertical axis (namely $3y^2x$) is used as a multiplier we have 24 rectangles, the sum of whose areas is $3y^5x+9y^4x^2+9y^3x^3+3y^2x^4$. In a similar way the remaining terms on the vertical axis are used as multipliers, yielding rectangles which fill the remaining part of the square whose area is $(y+x)^6$. The area represented is in all,

$$y^6+6y^5x+15y^4x^2+20y^3x^3+15y^2x^4+6yx^5+x^6.$$

The second term of this expression is represented by two larger rectangles each having an area $3y^5x$. They adjoin the two squares y^6 and $9y^4x$. They make contact with each other only at their corners, where a diagonal cross-line is drawn. The next term is represented by the square $9y^4x^2$ and two rectangles each having an area $3y^4x$, which make contact with the square at its corners. The areas representing the remaining terms will be readily identified.

The full significance of this diagram will perhaps be more fully realized, if the reader will multiply by ordinary algebraic process the two expanded binomials $(y+x)^3$ into each other. Each of the sixteen terms resulting will be recognized as placed in regular sequence in the square $(y+x)^6$.

For lecture purposes this diagram can easily be reproduced on a larger area, and it will then be an advantage to shade the small rectangles in which the exponent of x is odd. These areas must be considered subtractive if the sign of x is negative. The difference between the two sets of areas will then represent the area of a square, the sides of which have a length $(y-x)(y-x)(y-x)$. When the exponent n is odd, the diagram for $(y+x)^n$ will be a rectangle. If for example $n=9$, the sides of the rectangle similar to the square here shown, will have lengths $(y+x)^5$ and $(y+x)^4$. If the diagram becomes too large, the scale can be easily reduced, as is done in drawing a map of the United States.

Recent results published by the author seem to suggest a fairly satisfactory answer to the question, When is a cube not

a cube? The answer will be found in the adjoining diagram. As is well known the difference between the volumes of two cubes whose edges have a length y and x is found by dividing the quantity y^3-x^3 by $y-x$, and multiplying the factor $y-x$ into the resulting terms. We have,

$$y^3-x^3=y^2(y-x)+yx(y-x)+x^2(y-x).$$

These three terms are generally interpreted as representing the volumes of three blocks, which will fill the space between the two cubes. The terms of the second member may be written,

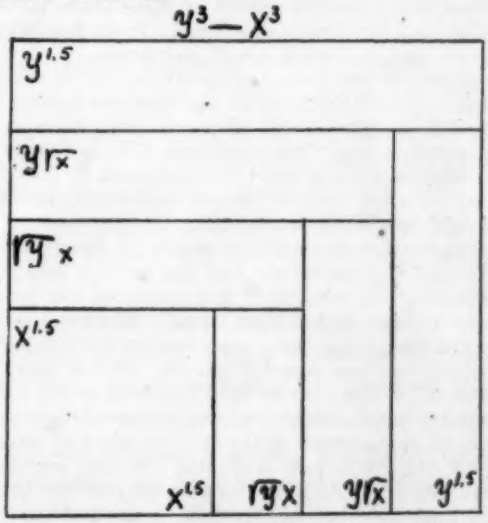
$$(y^3-y^2x)+(y^2x-yx^2)+(yx^2-x^3).$$

It is also well known that the difference between any two real quantities is equal to the product of the sum of the square roots of those quantities multiplied by the difference between them. The three terms in the above expression may therefore be written,

$$(\sqrt{y^3}-\sqrt{y^2x})(\sqrt{y^3}+\sqrt{y^2x})$$
$$+(\sqrt{y^2x}-\sqrt{yx^2})(\sqrt{y^2x}+\sqrt{yx^2})$$
$$+(\sqrt{yx^2}-\sqrt{x^3})(\sqrt{yx^2}+\sqrt{x^3}).$$

These terms are represented in the diagram, where y^3 is represented by a square area whose sides have a length $y^{\frac{3}{2}}$, and x^3 is represented by a square area whose sides have a length $x^{\frac{3}{2}}$.

The two factors in each of the three terms represent the width and the combined length of the rectangles which fill the area between these two cubes.



The function y^2-x^2 may be dealt with in a like manner. We have,

$$(y^2-x^2)=(y+x)(y-x).$$

This second member represents the area of two rectangles forming a strip between the sides of the two squares.

We may also write the second member in the form,

$$y(y-x)+x(y-x)=(y^2-yx)+(yx-x^2)$$
$$=(\sqrt{y^2}-\sqrt{yx})(\sqrt{y^2}+\sqrt{yx})$$
$$+(\sqrt{yx}-\sqrt{x^2})(\sqrt{yx}+\sqrt{x^2})$$

Here we have terms representing two strip areas between the sides of the squares y^2 and x^2. The widths of the two strips are $y-\sqrt{yx}$ and $\sqrt{yx}-x$.

The assumption made in this discussion is that each of the terms which are separated by the minus sign represents a quantity which is the square of some other quantity.

WOULD HONOR WAR HEROES ON ARBOR DAY.

Secretary of Agriculture Advocates Planting of Trees Dedicated to Men Who Died for America.

"Such an observance of Arbor Day as will secure a widespread planting of trees dedicated to those whose lives have been sacrificed in the great struggle to preserve American rights and the civilization of the world" is advocated by the Secretary of Agriculture, David F. Houston, in a letter just sent to the governors of the states.

The Secretary's letter follows:

"The observance of Arbor Day began soon after the Civil War. A distinguished citizen of Nebraska, who later became Secretary of Agriculture, was the prime mover in securing its recognition within his state, where it first took root; and the Board of Agriculture of that state, on his motion, designated the first Arbor Day. From the beginning it has had a civic motive and an association of patriotism.

"Another and greater war has come to its inevitable conclusion. The cause of righteousness, of liberty, of all that Americans hold dear has prevailed. We shall seek many ways to perpetuate the memory of those who made the great sacrifice. The memorials will take many forms. The names of those who have fallen will be perpetuated by costly monuments and inscribed on enduring tablets. Great works that serve the needs of peace also will doubtless be dedicated to them.

"But along with these memorials, we can easily discover ways in which we may simply and spontaneously pay our tribute to them. We can keep fresh our memory of what they gave; and we can perpetuate their names in familiar places. It has been happily suggested that we may do this by adorning with young trees, each named for a fallen soldier, our waysides, our yards, and our pleasure places. And in most of our states Arbor Day is at hand. This year we may give to that day a meaning more profound, a purpose more exalted, yet also an association more personal.

"I conceive that, if the origin of the day be borne in mind, the invitation to our fellow citizens to join in making it a day 'especially set apart and consecrated for tree planting' may appropriately come from this department. I take the liberty, therefore, of suggesting that you commend to the citizens of your state, and particularly to those in attendance upon its schools, such an observance of Arbor Day as will secure a widespread planting of trees, dedicated to those whose lives have been sacrificed in the great struggle to preserve American rights and the civilization of the world."

DIFFUSION, OSMOTIC PRESSURE, AND IMBIBITION IN HIGH SCHOOL BIOLOGY.

By Aleita Hopping,

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Osmosis is one of the difficult subjects to teach in high school biology. This is true partly because, as ordinarily presented in the classroom, it is not usually connected with any other familiar process, and partly because, when properly presented, it is found to be really much too difficult for elementary students. Osmosis was originally introduced into the high school work more than twenty years ago, probably because it was, at that time, the only physical process that could in any way explain the rise of water in tall trees. Osmotic movements, however, are much too slow to account for the rate at which the vast quantities of water, evaporated from the leaves, are drawn up through the tree trunks, and this process is generally not called upon at the present time, to explain these phenomena.[1] It is still a question whether absorption of water by roots is due directly to osmotic forces, or whether the turgidity of the cells is merely a condition that is necessary, the absorption of water being caused by other forces.[2]

The present discussion deals with some of the more recent interpretations of osmotic phenomena, and also shows how the subject is presented in many elementary texts. The method of handling the subject followed here is suggested for advanced classes. There is little necessity for the retention of the subject in elementary work, it is too academic in nature, and too complex. Practically all movements of foods and gases can be regarded either as mass movements due to mechanical forces, or as molecular movements of diffusion. In elementary classes, the simple laws of diffusion can adequately explain movements of foods, gases, etc.

Absorption of water, gases, and nutrients by the tissues and cells of plants and animals is universally met with in biological teaching, for these processes occur in digestion, respiration, cell nutrition, assimilation, excretion, photosynthesis, and, in fact, in almost all of the characteristic physiological activities of plants and animals. In elementary texts, and also in some of the more advanced ones, there appear to be at times conflicting ideas as to how these materials do enter into the plant or animal

[1] Dixon, H. H., *Transpiration and the Ascent of Sap*, London, 1915.
[2] Dixon, H. H., 1915.

body, how they pass through the tissues, and how the waste products are eliminated. It is perhaps more important that in elementary biological teaching these processes should be clearly defined, and their causes, so far as known, clearly stated, than in more advanced work, for in the latter case the students can of course search out for themselves a satisfactory account. It is thought possible that a brief treatment of this subject may be of service to teachers of high school biology. The method of presentation here may be regarded as somewhat didactic, but this is due to the complexity of the subject, and can scarcely be avoided. At the end, is an outline of the order in which the various topics may be presented in the classroom, but, of course, this is merely suggestive.

Critical Study of Texts.

Absorption of nutrients and gases in the body is closely connected in the texts with the subject of osmosis. Passage of nutrients from the food tube into blood and lymph, the absorption of water, of salts, and of gases, are in many cases explained as due to osmosis, though in other instances they are attributed to diffusion and imbibition. The term osmosis has been purposely avoided so far as possible in this discussion, since, in general, it appears to mean the diffusion of substances through membranes. The ability to diffuse is a property of all substances to a greater or less degree. Diffusion through a membrane is in no wise different from diffusion in a liquid where the diffusion is unimpeded by a membrane, though it may be somewhat slower, the membrane having a retarding effect. It is not expected that the older members of the profession will drop the term osmosis but for the newer ones, to whom the prospect of change is not so appalling, it may seem simpler and more logical to do this.

Among the different texts, elementary and advanced, the following quotations may be mentioned. Bigelow[3] defines osmosis as "the diffusion or absorption of water or solutions through a membrane without visible pores." He uses the verb "to osmose" to indicate that substances pass through membranes, thus being synonymous with "to diffuse." Clements[4] describes osmosis as the "purely physical process of diffusion." Davidson[5] defines osmosis as the "tendency of

[3]Bigelow, M. A., and Bigelow, A. N., *Introduction to Biology*, New York, 1913, page 46.
[4]Clements, F. E., *Plant Physiology and Ecology*, New York, 1907, pages 45-6.
[5]Davidson, Alvin *Human Body and Health*, New York, 1908, page 100.

two liquids of different densities when separated by a membrane, to mix." Findlay[6] defines osmosis as the "diffusion of substances through membranes." Brubaker[7] calls osmosis "the passage of molecules of water across an intervening membrane. The passage of dissolved substance across the membrane though usually included in the term osmosis, is more properly termed diffusion." Duggar[8] states that "the movement of the particles of the dissolved substance from the region of greater concentration to that of less, implies a force, or pressure, which may be termed osmosis, or diffusion tension." Washburn[9] gives the definition as "the passage of a liquid through a semipermeable membrane." Fischer[10] does not use the term osmosis at all but discusses diffusion and osmotic pressure.

Though the definition of osmosis is in general, diffusion of substances through membranes, this is not the only meaning given it. The definition given by Brubaker, and the one by Washburn, are evidently made in the attempt to give a more definite meaning to the term.

The so-called law of osmotic movements of liquids as stated by Clements[11], Ganong[12], Peabody[13], and others, is as follows:

"When two liquids of different densities are separated by a membrane, they pass through the membrane and mingle and the flow is always from the less dense to the more dense." This mode of statement is not met with in the most advanced texts. The terms dense and less dense in this connection appear to be unfortunate. Diffusive movements are always from regions of higher to those of lower concentration. Osmosis is defined as diffusion, but when the direction of osmotic movements is stated in this way, there is a direct contradiction, for diffusion always takes place from more to less concentrated conditions. Moreover, the terms dense and less dense are derived from the physical property of density. In its physical sense, density is the mass of a unit of volume. In the expression of osmotic movement, just given, density means the density of the solu-

[6]Findlay, Alexander, *Osmotic Pressure*, London, 1913.

[7]Brubaker, A. P., *Textbook of Human Physiology*, Philadelphia, 1908, page 230.

[8]Duggar, B. M., *Plant Physiology*, New York, 1913, pages 64-79.

[9]Washburn, E. W., *An Introduction to the Principles of Physical Chemistry*, New York, 1915, pages 128-9.

[10]Fischer, Martin, 1907.

[11]Clements, F. E., 1907.

[12]Ganong, William F., *A Textbook of Botany*, New York, 1916, page 228. Also, *The Living Plant*, New York, 1913, page 172.

[13]Peabody, J. E., and Hunt, A. E., *Elementary Plant Biology*, New York, 1912. page 35.

tions as a whole. But the density of the solution as a whole does not determine osmotic movements. If a porous clay cylinder with a membrane of cupric ferrocyanide is filled with a six per cent solution of gelatine, by weight, water will pass through the membrane into the sugar solution, though the outer solution is the denser. The osmotic pressure of this concentration of cane sugar is about 300 cm. of a mercury column, while that of the gelatine is only about 50 cm.

Density of the solutions as a whole, as has been said, does not determine osmotic movements, it is the molecular or particulate concentration. In solutions as in gases, substances are in the molecular state, and move independently of one another, and eventually occupy evenly the space at their disposal. Considering the concentrations of water in sugar, and sugar in water, when a thistle tube filled with cane-sugar solution is inverted in water, inside we have perhaps 25 per cent. of sugar and 75 per cent. of water, while outside, there is 100 per cent. of water, and 0 per cent. of sugar. Water would naturally then diffuse inward through the septum. Sugar would tend to diffuse outward, but is restrained by the membrane, which is impermeable, or slowly permeable to sugar. In cases where the membrane is permeable, the sugar does, of course, move out. There is no need to draw any distinction between diffusion and osmotic movements.

Not only is this expression of the "law of osmosis" confusing to students, it appears to be also confusing to teachers. Thus in one elementary textbook of biology, widely used throughout the country, this statement is met with: "To explain the process of osmosis we must remember that gases and liquids of different densities, when separated by a membrane, tend to flow toward each other and mingle, the greater flow always being in the direction of the denser medium."[14]

To determine in what direction an osmotic flow will occur, it is simple to consider that water, or solvent, will always be absorbed into the solute if it dissolves in the solute, and if the membrane is permeable to the solvent but not to the solute. The movement of water is still diffusion, but when the movement of the solute is prevented by the membrane, an osmotic pressure is developed.

As to the interpretation of biological phenomena in terms of diffusion and osmotic pressure, we find differences resulting from

[14]Hunter, G. W., 1914, page 75.

the different definitions of the term. When osmosis is defined as diffusion through a membrane, all the movements of gases and nutrients must be regarded as osmotic in nature. But by the "law of diffusion" substances move from the "more to the less dense," whereas by the "law of osmosis" (which is defined as being diffusion) substances move from the "less to the more dense." Hopeless confusion results. For this reason, it appears better to drop the term osmosis, and use in its place the term diffusion, or diffusion through a membrane.

Most of the membranes in the human body are remarkably permeable, and absorption of water by a solute through a semipermeable membrane is rare. This occurs when there are great differences in the osmotic pressure, in the food tube. For a full discussion of such movements of food in the body, Fischer's *Physiology of Alimentation* is probably the best.

Movements of Materials in General.

Movements of materials may occur as mass movements produced by mechanical forces where the body moves as a whole, or may occur as molecular movements where the substance exists in a highly divided or dispersed state, and where the movement is due to the intrinsic energy of the molecules composing the substance. Mass movements in animals are exemplified in the circulation of the blood and lymph, and also in the taking in and giving out of air during breathing, by muscular movements, etc. In plants, mass movements are the exception, not the rule. The upward movement of water through the plant from the roots to the leaves in the transpiration stream is regarded as a mass movement set in action by the evaporating power of the air. Convection currents caused by unequal heating of the internal atmosphere of the plant, currents caused by mechanical bendings due to wind, streaming movements of protoplasm are also examples of mass movements. Molecular movements occur when gases or dissolved substances diffuse, when water or other liquids are absorbed by colloids (imbibition), and as a result of the molecular attraction that exists between molecules of various substances. Of these diffusion and imbibition are, from our viewpoint, most important.

As is well known, in order to account for the behavior of material bodies, it was early supposed that they were made up of very small particles in a continual state of rapid and constant, unordered movement. These particles were called molecules. The

examination of a drop of pure liquid fails to reveal any such rapidly moving bodies, and so if there are any, they must be beyond the range of the most powerful microscopes. However, the presence of visible particles possessing an irregular motion was noticed by Robert Brown[15], while examining with a microscope a liquid containing pollen grains. Later investigations showed that the movement was independent of the nature of the particles, it was more rapid the smaller the particles, and it was persistent, and never changing. It is supposed that this Brownian movement is the result of molecular motion within the liquid. The small visible particles are knocked about by colliding with the invisible molecules. This Brownian movement is, of course, a visible evidence of the kinetic evidence of molecules, which results in diffusion or dispersal of gases or of dissolved substances.

Since diffusion and imbibition are molecular in nature, it is necessary in teaching the subject that some conception of molecules be developed. There is, of course, no way of demonstrating the actual existence of molecules, but as we have seen, tiny particules in rapid, unordered movement can be seen under the microscope, in suspensions of finely divided materials. Similarly, it is possible to see tiny dust particles, ordinarily invisible, in a ray of light falling in a dark room. As a classroom demonstration, to show spontaneous movement of tiny particles, a powerful incandescent lamp may be enclosed in a box that is impervious to light, and is provided with a small opening. The tiny particles can then be seen in rapid movement in the beam of light. This sort of thing is of course, familiar to all. The light from a moving picture machine shows the same thing. When a searchlight is thrown from a steamer, those on deck can see the brightly illuminated and moving particles in the beam.

Such spontaneous movements of particles, ordinarily invisible, do give conceptions upon which can be built the idea of the existence and movements of molecules.

Diffusion.

Confined gases when released spread in all directions, as a result of the intrinsic energy of the molecules composing them, and eventually occupy evenly all the space at their disposal. Thus if a cubic centimeter of hydrogen is placed in a sealed vacuum chamber, it will completely fill the chamber, however large it may be. This process of expansion is called diffusion. Because of this outward tendency to expand, an outward pres-

[15]Perrin, J., *Brownian Movement and Molecular Reality*, trans. by F. Soddy, 1911.

sure, called gas pressure, is exerted upon the walls of the confining chamber, and the pressure is supposed to be caused by the continuous bombardment of the walls of the enclosing vessel by the vibrating gas particles. For a given amount of gas, the pressure is constant at a constant temperature, but any change in temperature means a change in the kinetic energy of the particles. Experimentally, it has been found that the volume of a given mass of gas under constant pressure varies directly with its absolute temperature. It has been shown also that the volume of a given mass of gas at constant temperature varies inversely as the external pressure to which it is subjected. Also for a given concentration and temperature all gases exhibit the same pressure. That is, equal volumes of gases at equal temperature and pressure contain the same number of particles. These are of course the well known gas laws.

In a mixture of several gases each gas exerts practically its own pressure independently of the others. Thus the total pressure of a mixture of gases in a chamber is the sum of the pressures which would be exhibited were the gases separated and each put into a chamber of the same size, the temperature remaining constant. The total pressure of a gas mixture is practically the sum of the partial pressures of its component gases.

When two different gases are separated by a porous septum, an interchange takes place between the two, and ultimately the composition of the gas on both sides of the septum becomes the same. The rapidity with which different gases diffuse varies considerably. The rate of diffusion depends upon the mass of the molecules, on the densities of the gas. The lightest gases diffuse most rapidly. If hydrogen and chlorine are separated by a porous membrane, the rate of diffusion can be studied by noting the movement of the yellow color of the chlorine. Each gas moves independently of the other and tends to occupy evenly the space at its disposal without regard to the presence of the other. The direction of movement is, of course, always from regions of *greater* to regions of *lower* concentrations. The cause of the movement is regarded as being due to the kinetic energy of the molecules, or, in other words, it is a characteristic of molecules that they are always in very rapid, and undirected movements. Heat from the surroundings increases the kinetic energy and increases the rate of diffusion. The rate of diffusion then depends upon the temperature, and the density of the diffusing gas.

The property of diffusion is also characteristic of liquids. When a liquid is heated the kinetic energy of its particles is increased, until finally the cohesive force which held them together is overcome; they then fly off from the main mass and diffuse indefinitely. This is the process of vaporization by heat. All substances, if the temperature is high enough, can be vaporized. Also many liquids at ordinary temperatures gradually evaporate. If a liquid is confined in a closed chamber vaporization after a while ceases. The gas pressure with which the liquid particles escape is termed vapor tension.

If two different liquids of different colors are separated by a porous septum, diffusion occurs between these two until they are evenly mixed, and the rate of diffusion can be determined by studying the intermixing of the colors. Solids when suspended in a liquid in which they dissolve, also diffuse. If a crystal of copper sulphate weighing ten grams is suspended in the center of a cylinder filled with water, after some time the blue color of the sulphate will be seen spreading above and below throughout the cylinder. When the crystal is completely dissolved in the water, if the contents of cylinder are separated into two equal portions, it will be found that five grams of the sulphate diffused upward and five grams downward. This is an example of solution diffusion, as distinguished from gas diffusion. Diffusion is very slow. It is more rapid at high tempatures, is measured by the degree to which the solute is soluble in the solvent, and upon the concentration. The direction of solution diffusion is also from regions of higher to regions of lower concentration. The cause of the movement is attributed to the kinetic energy of the particles of dissolved substance.

Solid substances diffuse and mingle with one another, though with extreme slowness. For instance, solid carbon is capable of passing through a porcelain septim and distributing itself evenly through a mass of iron particles. There are many examples of a similar kind, and the resulting mixture is called a solid solution. They have only theoretical interest.

The theory of the kinetic energy of the particles in solution is rendered very interesting in the light of the calculations of the velocity of movement of the hydrogen ion in solution, which showed that it has the same velocity as in the gaseous state.[16]

Osmotic Pressure.

If a parchment paper bag be filled with a strong sugar solution,

[16]Soddy, Frederick, *Matter and Energy*, London, 1912.

and after being sealed be submerged in water, the bag will soon be distended by an internal pressure. The wall will be stretched and may be ruptured. While the bag is whole, if the water around it be tested for sugar, little or no sugar will be found; after the bag is ruptured, however, the sugar diffuses rapidly to the limits of the water. Parchment paper hinders greatly the diffusion of sugar, it is only slightly permeable to dissolved sugar molecules. The pressure produced upon the walls is evidently due to bombardment of the walls by the sugar molecules, and is really a measure of the tendency of the molecules to diffuse (diffusion tension).

Such a membrane as parchment paper, which allows the solvent to pass, but prevents or retards the passage of solute particles, is said to be semipermeable, or selectively permeable. The pressure which such a membrane makes evident is the osmotic pressure of the solute. This is the diffusion tension of the solute made evident by the opposition of the membrane.

If a porous cylinder is filled with copper sulphate solution and placed in a solution of potassium ferrocyanide, a membrane of copper ferrocyanide is formed in the porous walls. If the copper sulphate is then replaced by a cane-sugar solution and the cup surrounded with water, the solvent passes into the sugar solution through the membrane. If this movement is not opposed, the diluted sugar solution rises above the level of the water outside, and a hydrostatic pressure on the solution is produced. Depending on the concentration of the sugar solution, the movement will continue until a certain level is attained, after that no further rise occurs. This hydrostatic pressure then becomes a measure of the osmotic pressure of the cane sugar solution. To obtain the most perfect results it is necessary that the membrane be permeable to the water but quite impermeable to the sugar, otherwise the sugar, of course, will leak out and the osmotic values be too low. Perfect semipermeable membranes are rare, but that there is such a thing is shown by experiments where for a space of sixty days at temperature of 15° C. a membrane of copper ferrocyanide maintained a pressure of over twelve atmospheres, without leakage.

Measurements of osmotic pressure by Pfeffer[17] and others have shown that the pressure is directly proportional to the concentration of the solution and that it increases with increase in temperature, and thus obeys the gas laws.

[17]Pfeffer, W., *Osmotische Untersuchungen*, 1877.

The passage or diffusion of substances through membranes is ordinarily called osmosis. The question arises, how substances do pass through the membranes. The solubility theory suggests that they dissolve in the membrane and pass by diffusion through it. An experiment which illustrates this is as follows. Choloroform, water, and ether are placed in layers in a test tube, in the order named. The ether passes through the water and enters the choloform. If this movement is resisted, a pressure similar to osmotic pressure becomes evident. Ether dissolves in both water and chloroform. Chloroform does not dissolve in water. The water acts as a semipermeable membrane, permeable to ether; impermeable to choloroform.

(To be continued in June.)

A CALIFORNIA COAL THAT IS RICH IN OIL.

For many years lignite mined near Ione, Calif., has been used as fuel, though it contains a large quantity of moisture and therefore does not burn very well. Recently, however, on account of its resemblance to some oil shales that are apparently similar to cannel coals, this lignite has been tested by the United States Geological Survey, Department of the Interior, to determine whether it would not yield oil on destructive distillation. The results of the tests show that the best of the lignite, when destructively distilled, will yield 62 gallons of oil to the ton, and, as a by-product, at least 18 pounds of ammonium sulphate, which is a valuable fertilizer. This lignite is remarkably "fat." Although it contains 46 per cent of moisture, analysis made by the Bureau of Mines shows that it contains also 31 per cent of volatile matter and 16 per cent of fixed carbon. The ash amounts to only 7 per cent, and the heating value is 6,060 British thermal units.

Although the bed containing this lignite does not appear to underlie a large territory, it is doubtless destined to receive attention sooner or later as a possible source of oil and gasoline.

USE OF GLOW LAMPS FOR PROJECTION APPARATUS.

O. Kruh, the author, investigates, by the aid of formulas, the characteristics of glow-lamp filaments lending themselves to optical projection. A table of intrinsic brilliancies of the chief illuminants is given. Improvements have been made by mounting filaments as adjacent bars close together and increasing the diameter so as to use larger currents. The effect of altering the space between adjacent filaments is discussed. The chief difficulty in making lamps for very high currents has hitherto been the mounting of the leading-in wires. This, the author states, has been overcome, and lamps consuming up to 200 amp., giving 30,000 cp. to 40,000 cp. (Hefner) and working at 0.25 watt per candlepower (Helner), have been made. The candlepower attainable is limited only by the size of the bulb, but up to 100,000 cp. could be obtained if there were need. The effective intrinsic brilliancy of the source can also be increased by placing a mirror behind it, forming an image of the filaments in the spaces between the successive bars. In this way an intrinsic brilliancy of 70 cp. per millimeter, approaching that of the carbon arc, can be secured.—[*Electrical World.*

NOTES ON BIOLOGY TEACHING.

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IV

First Term Class; Papers of a Written Test on "Food" Returned and Examined in Class.

Girl reads clipping on meat substitutes. "The formula recommended is infinitely better and cheaper than that of the sausage factory." I would suggest that not only should our dietary standard be better than that of the sausage factory, but that our language standard be, if not infinitely, at least measurably, better than that of the journalist quoted.

The advantages of using hash. Several pupils spoke; there were nearly as many points as there were pupils. A summation with enumeration would be of value at the conclusion of such an exercise.

The expression "more nourishing" was used repeatedly, e. g., potatoes more or less nourishing than meat. I feel that it is a part of the business of our teaching to eliminate the use of such obscuring speech forms.

We need food for building material. "We need food for another work that we do." "Food that is going to burn up and oxidize and enable us to work." Look out for choice of words: You must make the ideas go over the top, and you must avoid putting over vague clouds of words that produce no effect of value in the cerebrum.

Until a group of ideas that you wish to have permanently associated have become so thoroughly drilled in as to recall each other automatically, it is well to use the blackboard in addition to the verbal representation, even when there are only two items, e. g., *fuel* and *building material*.

"Oxidation should always suggest the picture of a burning candle." Why should it? It doesn't to me, and I think I understand oxidation about as well as most high school graduates. Indeed it has been one of the obstacles to an understanding of oxidation that teachers have insisted upon the picture of a candle flame standing as the symbol for a much more subtle process than this picture can possibly suggest. As the concept *oxidation* expands it should become less and less possible to visualize it so concretely. Is it not part of your purpose to assimilate to the concept oxidation such processes as, e. g., the rusting of iron, the blacking of pyrogallol, the oxygenation of hemoglobin,

and oxidation within living tissues? If it is, should it not be your purpose to have the pupils get rid of the candle flame as a symbol, and to teach them to attach to the word *oxidation*, whether written or spoken, all of these ideas? "The content and the extent of a concept vary inversely." The more you know about *life* the less able are you to visualize it concretely; and so with *oxidation*, and so with every other concept.

Is the smaller size of the Mongols related to their diet? Are the Japs a stunted race or a smaller race? Are the Eskimos who probably have an excess of protein and a deficiency of carbohydrate in their diet, small because of the excess of fat, or because of some congenital factor not yet determined? It is no doubt true that the deterioration observed by the British health officials in successive periods during the nineteenth century, when examining men for the armies, was related to factors of nutrition, fatigue, and other environmental conditions; it does not follow, however, that this alone will produce a "stunted race."

One girl had a perfectly logical sequence based on the unconscious hypothesis that a certain race *lives exclusively on fuel foods*, but it did not hurt her to accept the hypothesis. There was evidently a gap in that girl's mental fabric which neither she nor you had noticed.

It seems to me that your pupils give you an unusual opportunity to discover whether on the whole girls are as capable of inductive thinking as are boys; but that you are not pushing the opportunity as vigorously as you might.

Perhaps you still feel the need for insuring a reasonable amount of reliable information; and with the attention on the information there is some danger of neglecting the mental processes through which the pupils attain to their store of knowledge and belief and understanding.

LESSON ON DIET.

You have a good feeling for the use of the blackboard. I would suggest that you use the "print letters" where you make a schedule or table; I think it is more effective than cursive handwriting, except for an occasional word or phrase.

In comparing the diet of a thin person with that of a stout person, you overlook the fact that the part of the "person" which is significant in questions of diet is the *living* part. That is to say, the protoplasm. The calculation of diet is based on activity and maintenance of weight and not on gross bulk.

Generally speaking, the pupils did not seem to be clear as to

the functions of food or as to the classification. Most of the pupils remember that proteins are necessary, "because they contain nitrogen"; but the relation of proteins and of the other nutrients to the living substance, that is, to the metabolism, seemed rather obscure.

In discussing balanced diet, keep in mind as an end to the study, the idea of *what are the factors to be balanced.* Most students finish up with the notion that balanced means simply some arbitrary or some proper ratio between protein and other materials. The dynamic aspect needs to be made clear, namely, that we are to secure a balance between *income* (of food) and *outgo* (of energy and of the by-products of metabolism.)

You asked for opinions as to whether carbohydrates would be sufficient as an exclusive diet: Nobody has any opinion, nobody seems to care. This situation, by the way, occurred repeatedly: It is only the pupil who is "reciting," those in his immediate neighborhood and two or three conscientious pupils who are attending. Most of the time, the rest of the class, though quiet enough, seem merely to be waiting. This I attribute to the rather placid manner which you have. You have not found a way to interest most of the pupils most of the time.

One girl eats meat because it contains fat, and she needs "as much fat as she does protein." How can you let a thing like that get by you?

It was not clear whether an exclusive protein diet is still a possible one. This point is important, however, only if we are to understand the *functions* of foods and not merely *rules* for standard diet.

Do you think that if you followed a syllabus of your own you would be less formal in the organization and presentation of your subject matter? I should think that from time to time, you would feel like introducing ideas suggested by your father's medical experience, but would hesitate because of the schedule which you have laid out for the work. I wish you would feel more free to develop ideas of your own, and not confine yourself to the typewritten plans of the department, it would give more swing to your work.

VI.

CLASS STUDYING BACTERIA.

You have a very good example of the conflict between the "logical" in teaching and the "psychological." The pupils were interested; they were aroused to make suggestions, they were

drawing upon all their resources to help you in the problem you had placed before the class—that of organizing a schedule on the subject of bacteria.

You had in your mind the general features of this schedule; and you framed your questions to get the major items in your own sequence. But why, in the name of bacteria, or of common sense, must the question, "Where are bacteria found?" take precedence over the question, "Of what use are bacteria to man?" It was only because you had planned too rigorously in advance that the students' question was forced to take its place in an arbitrary line in which you had reserved favored places for other questions that really came later—*so far as the students were concerned.*

Under the item, "Where bacteria are found," there seems to me to have been a lapse in the logic. You have enumerated as (*a*), (*b*), (*c*), (*d*), etc., street, garbage pail, picture moulding, soiled hands, etc., etc., items that could have been extended indefinitely. Does this series represent *categories*, or does it represent *examples?* As a matter of fact you missed the significance of your own question, which was, I take it, to determine *habitat.* Otherwise, the answer to the question could be given in one word—*everywhere.* The point is not their ubiquity, but the conditions under which they maintain their vitality. It was necessary, it seems to me, to bring out two factors of the habitat: moisture and organic material. The dust and soil and dirt on a boy's hands represent *vehicles* and not *media.*

The word "germ" was introduced as a substitute for microbe, and was ruled out under the impression that the word meant something harmful. The inhibiting thought in the back of your mind was the presence of many "germs" that are beneficial. Nevertheless, the word "germ" as related to diseases has a direct connection with the word "germ" as it occurs in other associations, for example, *germ cell, germ plasm, germinate, germ in a seed,* etc. Since you do take the time to detach the word from its specialized meaning as a vulgar synonym for microbe, is it not worth while to give its etymology and its implications in these other connections with which it is likely to be used?

Uses of bacteria classified as:

(*a*) Harmful.

(*b*) Harmless.

Generally speaking, these categories, (*a*) and (*b*), do not meet our

common experience; and specifically they are not adequate for dealing with our relations to the bacteria. There are also beneficial classes.

You called attention to the fact that the word *bacteria* is a plural noun. Yet several pupils used it in the singular without being corrected.

It is well to have every lesson prepared in advance. It is still better, however, to lay aside a plan, however carefully prepared, and utilize the thoughts and questions of the children as the warp upon which your pattern of ideas and principles is to be woven.

VII.

Class in Hygiene.

The plan of having individual pupil take charge while presenting his own report and while receiving questions, comments, and criticisms is very good. While it encourages the initiative, where there is any, there is the danger, however, of neglecting the very pupils who need most to be put on their feet. The indifferent or the unconcerned pupil is likely to be overlooked unless the teacher discovers him and puts him forward.

Discussion of "substitutes" for alcohol (in medicinal matters) was not left very clear, I am afraid.

"Why does alcohol make the skin cooler, when applied externally, and the inside of the body warmer, when taken internally?" This is a real question and deserving of a real answer. An adequate answer, I take it, is one that is based on casual relations, not on magic. To emphasize the facts and leave behind a glow of wonder at the queer antics of this strange liquid is to breed mysticism and fatalism. But any other kind of answer must take into account (*a*) the physics of evaporating liquids; and (*b*) the chemistry of oxidation; and (*c*) the physiology of energesis. This means introducing new ideas; but without going too far afield. The evaporation facts that are pertinent are already within our possession. A wet hand feels colder in the air than a dry one; a porous clay jug keeps water cooler than an impervious vessel; a damp cloth is placed about a bottle to keep it cool; the evaporation of water from a vessel involves the removal of heat. Fire gives off heat; glowing embers or incense give off heat; rusting of iron gives off heat. The heat of the body is derived from the oxidation of certain organic substances in our "food"; alcohol is absorbable and oxidizable. There is nothing of the demon or the perverse that gives us the contradictory behavior of alcohol.

"Oxygen is too strong (or rich) to breathe; therefore Nature (or nature) has diluted it with nitrogen." To be sure, we cannot stop to go into the metaphysics of what Nature had in mind when she invented nitrogen, or as to why this rather than some other inert gas was selected for the dilution. But must we tolerate the assumption implied in such a statement? So far as the pupils are concerned it is sufficient that the composition of the air is what it has been found to be. Neither you nor I nor any of the others know just yet "why" it has this composition rather than any one of an infinite number of possible others. Moreover, while it *may* be true that an atmosphere of nearly pure oxygen would be too strong for the maintenance of vital processes, we should note (*a*) that we know nothing about that; and (*b*) it doesn't matter.

"Deep breathing is good so we can grow better." Perhaps. What's the big idea?

"The *active* organs involved in breathing." Apparently seeking the dynamic elements. But just what was meant? Is the lung "active" in breathing? If so, what does "active" mean? If not, what does the question mean? The lungs play a characteristically passive part in the whole process. The implications of your analysis are that the act of inspiring (or of expiring) somehow takes place, either automatically or at will, and drags in as its consequences the movement of the diaphram, of the ribs and the breast bone, and the displacement of the abdominal organs. The fact is that the *movements* concerned in "breathing" are those brought about by the contractions of certain muscles—the intercostal and the diaphragm, chiefly; that these movements result in enlarging or contracting the chest cavity; that these variations in the volume of the chest cavity result (because of air pressure) in the filling or emptying of the lung sacs. The movement of the diaphragm (which is always a downward movement, since the relaxed condition of the muscles go with the upper position) results in the displacement of the abdominal organs. This displacement is in no sense an "action involved in breathing"—although it is certainly an indication of the force, form, and frequency of the breathing movements. A bit of cloth in front of a ventilator opening is blown by the incoming air; it flutters so long as the ventilator is working, and hangs limp when the ventilator stops blowing; but it is in no sense one of the "active" parts of the ventilator system, although it is very active when the ventilator is at work, and not otherwise. So with the abdomen in breathing, *and so with the lungs!* The logical defect

of your presentation was the fallacy of "post hoc"—that is, the reasoning that "after, therefore because." The slip came when you used the word "when" in a way that meant merely *time* but implied *cause*. Pedagogically, you would avoid this by beginning at the other end: present the lungs for what they are, and then raise the question, "How is the air made to pass into and out of the lungs?"

"Go to the experiment" and show how the lungs work, etc. Just what is an "experiment"? Is it a stunt performed in a "laboratory"? Or is it a "scientific" gimcrack? I suppose one should not be too jealous of the words of the language, especially in a free country; nor should one be pedantic about the technical words in his specialty. But I confess that I have very strong prejudices concerning such words as "experiment."

"The stomach is a small organ" in the abdomen; "about as small as your fist." That means. . . . . .?

"How many agree?" "How many do not agree?" Legitimate and often desirable. But look out for the fact that some pupils fail to respond to either alternative.

SUPERSATURATION AND CRYSTALLIZATION.

By G. Ross Robertson.

Supersaturation and crystallization by "seeding" are shown in a fascinating way with benzil. Five grams benzil is dissolved in fifty cc. hot alcohol. The solution is filtered through coarse paper in a warm funnel into a two to three hundred cc. flask. It is brought to a boil, and at once set aside in a quiet place. The flask is now fanned so that the glass walls will cool and collect condensed alcohol, which washes down any benzil and prevents marginal crystallization before the desired time. With ordinary care the solution does not crystallize if not shaken.

When the liquid cools to 15° to 25° C., an extremely minute crystal of benzil is dropped exactly in the center of the flask. The surface tension breaks, and crystals fly radially all over the surface. Soon a complex design of beautiful lemon yellow prisms spreads through the mass, and after a few minutes the prisms grow to long rods which span the base of the flask.

The experiment is of course a classic favorite, using sodium salts. These, however, do not give the neat color effect obtained with benzil. By using a thin, clear, crystallizing dish, the phenomena can be shown to advantage with the vertical projector of a modern stereopticon.

For illustration of simple crystallization upon the screen, dissolve about six to seven grams pure copper sulphate crystals in ten cc. hot water. Rub a blank slide with the finger so that it will be just greasy enough to prevent spread of water, and place in vertical projector. Pour a couple of cc. CaSO solution on the slide. No seeding is needed, and the crystals show up in splendid shape in the course of two to five minutes.

Benzil, or diphenyl diketone, is easily made with common apparatus. Benzaldehyde and KCN or NaCN are the special reagents. It is easy to obtain a good yield, using procedure described in the Gattermann, E. Fischer, and other organic manuals.

RESEARCH IN PHYSICS.

Conducted by Homer L. Dodge.

State University of Iowa, Representing the American Physical Society.

It is the object of this department to present to teachers of physics the results of recent research. In so far as is possible, the articles and items will be non-technical, and it is hoped that they will furnish material which will be of value in the classroom. Suggestions and contributions should be sent to H. L. Dodge, Department of Physics, State University of Iowa, Iowa City, Iowa.

THE THERMIONIC AMPLIFIER.

The thermionic amplifier consists essentially of an evacuated vessel containing a hot cathode, an anode placed at a convenient distance from the cathode, and a third electrode adjacent to the cathode. This auxiliary electrode may be in the form of a grid placed between the cathode and anode. The cathode usually consists of a filament which can be heated by passing an electric current through it. If the anode be made positive with respect to the filament, the electrons emitted from the hot filament travel to the anode, and the current thus established in the circuit connecting the filament and anode can be varied by potential variations applied to the auxiliary electrode.

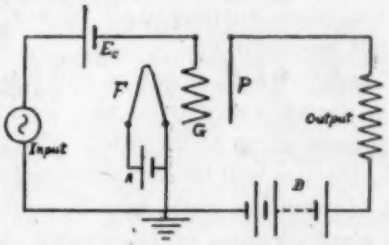
We have already discussed in this department the action of a thermionic bulb, possessing a single anode, used as a rectifier of very small currents. Such an instrument puts the energy in a form in which it can be used to advantage but it does not increase the available energy.

When the thermionic device is fitted with the auxiliary anode it becomes capable of a much wider usefulness. It becomes a thermionic amplifier. It is not an amplifier in the sense that it manufactures a large amount of energy out of a small amount but it does amplify in the sense that it makes it possible for a very small amount of energy coming from a distant source to control a very large amount of local energy. In other words it is a relay.

Everyone is familiar with the ordinary telegraph relay which, operating on the weak current coming over many miles of wire, makes and breaks a delicately adjusted contact in a local circuit, the local current being strong enough to operate the sounder. Such an instrument is capable of handling the Morse alphabet of dots and dashes. It can turn the local energy completely on or completely off. The thermionic amplifier is a similar device in about the same way that all printing presses are alike and it differs from the telegraph relay as a modern rotary press differs from the hand press of Franklin. The thermionic amplifier can

not only turn the local energy on and off but can also regulate its flow to correspond to every shade of difference in the incoming current which, if a telephonic current, will possess all the delicate modulation of the human voice.

In explaining the action of the amplifier we shall assume that it operates under conditions such that no appreciable ionization by collision takes place.[1] The current between the filament and the plate consists of a flow of negative electrons from the filament to the plate. We shall also assume that the filament is at such a temperature that the number of electrons emitted is in excess of the number which the positively charged plate is able to draw to itself. Under these conditions the current in the plate circuit will depend upon any factor which alters the electric field between filament and plate. It is this function which the auxiliary electrode performs.



To get an idea of the effect of the auxiliary electrode consider the circuit shown in the figure. F denotes the cathode, which is a filament heated by the battery A. P denotes the anode or plate and G the auxiliary electrode which is in the form of a grid between F and P. Let the potential of F be zero, and that of P maintained positive by the battery B, and let E_c for the present be zero. Although there is no potential difference between F and G, the electric field between F and G is not zero, but has a finite value which depends upon the potential of P. This is due to the fact that the potential of P causes a stray field to act through the openings of the grid. The actual field between F and G will be the same as would exist were there an imaginary plane surface S, coincident with G, charged to a potential E_c. Since the plate is always positive, E_c is always positive. It is a function of the potential of the plate, the particular function depending upon such factors as the mesh, size, and position of the grid. Under the influence of the field represented by E_c the electrons are drawn through the openings of the grid

[1]For a discussion of a thermionic device making use of ionization by collision see "A Thermionic Amplifier for Large Currents" in the March number.

and are thrown upon the anode by the strong field existing between the grid and the anode.

The effect of the potential E_g of the grid upon the motion of electrons between F and G will now be considered. Whether or not electrons will be drawn away from the cathode depends on the resultant value of E_a and E_g. If E_a+E_g is positive, electrons will flow away from the cathode. If E_a+E_g is zero or negative, all the emitted electrons will be returned to the cathode and the current from the filament to the plate reduced to zero.

Since E_a is always positive, E_a+E_g will be positive when E_g is positive and also when E_g is negative and less than E_a. In the first case, with E_g positive, some of the electrons are drawn to the grid while the rest are drawn through the openings of the grid to the anode. In order that the amplifier shall operate successfully it is necessary that this robbery, by the grid, of electrons from the plate current shall be negligible. In other words E_g must not be positive.[2]

In the second case, with E_g negative and less than E_a, nearly all the electrons drawn away from the filament pass to the plate, practically none going to the grid. The greater the arithmetic value of E_g the less will be the current of electrons passing through the grid of the plate, until, with E_g equal to E_a, the plate current will be zero. Values of E_g greater than E_a will consequently have no further effect upon the plate current.

A brief consideration of the above facts shows that a change in the applied voltage E_g within the limits mentioned, namely between zero and $-E_a$, will produce a corresponding change in the plate current. It is necessary that the applied voltage remain within these limits if fluctuations in the applied voltage are to be followed at all exactly by the changes in the plate current.

These limitations, together with the fact that the voltages to be amplified are alternating potentials, makes it necessary to insert a battery E_c in the input circuit to hold the grid normally at a negative potential. E_c is made equal, numerically, to one half E_a. The alternating potential may have a maximum value of E_c. Under these conditions the grid will never be positive and will never have a negative value greater than E_a. The current in the plate or output circuit will follow the voltage fluctuations in the grid or input circuit. In the practical operation of the

[2]This is not strictly true. In this discussion we are sketching the bare framework of the theory of the amplifier. Those who are interested in the subject should consult the paper of H. J. van der Bijl in the *Physical Review* of September, 1918, from which much of our material is taken.

tubes it is often found possible to dispense with the battery E_c, the grid keeping itself negative for the greater part of the time by attracting to itself electrons whenever it becomes positive.

A very interesting feature is that no current flows in the input circuit, at least under the conditions we are considering. The impedance of the input circuit is infinite, for no electrons can pass between filament and grid. Consequently the device cannot react upon the source of potential and change the character of the incoming flow of energy. This helps to keep down the distortion which is always such an important factor in any scheme for amplification. Moreover this high impedance means that the amount of energy necessary to operate the device is vanishingly small.

Although but little energy is necessary to operate the device the amount of energy available in the output circuit is comparatively large. A single tube can easily be made to deliver a hundred watts or more. Voltage amplification of a hundred fold is not difficult to obtain while a power amplification of 3,000 fold is possible with a plate voltage of only 100 volts.

Thermionic devices of this type are used extensively in radio telegraphy for sending and receiving. They are essential to radio telephony and to long distance wire telephony. The great progress during the war in all forms of electric signalling has been due largely to the development and application of thermionic amplifiers. A sixty pound equipment on an airplane, using three tubes, has made conversation possible between two flying planes ten miles apart. With seven tubes in cascade, using only a ten foot loop of wire for an antenna, signals originating in France have been heard in New Jersey. In this case the amplification reaches several hundred thousand fold. Equally astonishing is the fact that these same devices, at the sending station, make it possible for the voice to modulate power amounting to several horse power.

SIXTY BILLION DOLLARS INCOME.

Figures mean little when they run up to eleven places, but it is comfortable to think that the national income now amounts to $60,000,000,000. This is double the total of 1910. It shows the enormous stimulation of activity under the stress of war. More than that, it gives a slight idea of the immense potentialities of the United States.

Sixty billion dollars a year means $580 for every man, woman and child in the United States. The New York statisticians figure that the total wealth of this country is now double that of England and the national income quadruple.

A FOOL-PROOF SWITCH BOARD.

By T. L. Harley,
Hyde Park High School, Chicago, Ill.

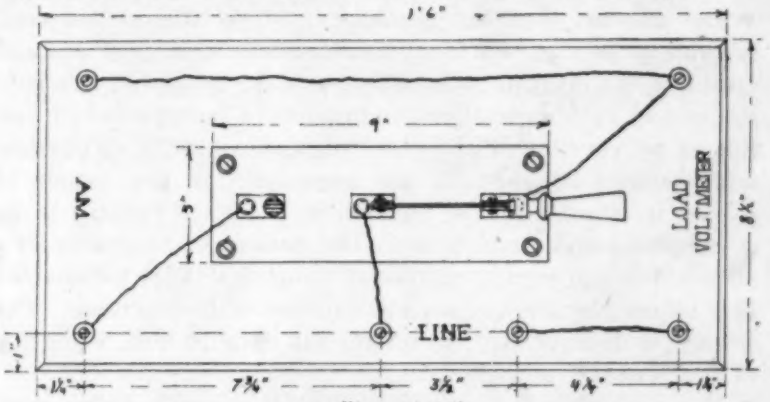
Our new Physics laboratory in the Hyde Park High School is equipped with wiring and switch-board control for a. c. and d. c. currents, the latter in voltages ranging from 0 to 150. Our plans for student equipment provided for enough meters to give each of thirty-two pupils a voltmeter and an ammeter. We looked forward confidently to a new order of things in teaching electricity.

The first joy we felt at having sixty-four 3-range Weston meters was tempered very seriously at the end of the first season's use by an inspection of the instruments, which showed seventeen of them out of repair. Some had burned-out coils, some bent hands, several ammeters had one shunt burned out, while one had all three gone. All showed indubitable proof of the heedlessness or carelessness of youth. Our repair bill the first season was over fifty dollars.

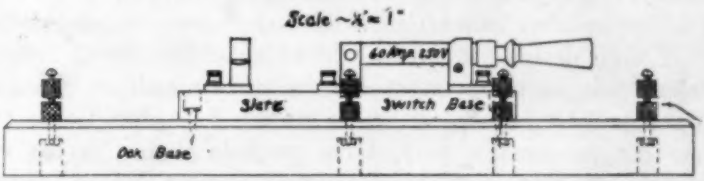
The second and third seasons we had somewhat better success, due to our knowledge of the risks inexperienced students were putting our valuable instruments to, but every year in spite of the closest watch we could keep, we finished with a number of instruments out of repair. The fact that the students knew that they were watched closely eliminated careless short-circuits, but did not cut out those due to ignorance. I became convinced that it was necessary to make some protective device by which ignorant blunders in wiring up apparatus should not result in fatalities to the meters.

The switch-board shown herewith is the outcome of that project. It is made up on a solid wood base 2x9x18 inches. Three pairs of binding posts connect the board to the "Line," to the "Load" (including the voltmeter), and to the "Ammeter," respectively, each pair of posts being plainly marked. As the students are making connections, they are taught to keep the double-throw switch in neutral position. Then as they finish making connections and plug in to the outlet boxes for current from the line, they are taught to throw the switch into position marked (1) on the switch base. Then if they have made a short-circuit anywhere, the light fuse in the outlet box (5-A) blows out. The voltmeter to a large extent is self-protecting on the high range so that in case of a "short," it is not injured. The blowing out of the fuse warns the students of their blunder in wiring, whereupon they either locate the trouble themselves

or call the teacher. When they are again ready to proceed, they first throw the switch again into position marked (1), then after a few moments, the fuse holding, they throw over to position (2). In position (2) both voltmeter and ammeter connections are made and readings can be had directly.



HARLEY'S
UNIVERSAL SWITCHBOARD



When this device was first worked out, I had in mind but the one thought of some means to save our meters. A second feature that worked out incidentally has proven of even greater educational value than the first which had to do with property-saving. I soon found it necessary to show them but once how to wire up the board for any electrical device, because by the use of that they could readily see that there is only one way to wire up, and that once that method is learned, they have it learned for all devices. One pair of posts is marked "Line," another "Ammeter," and the third pair "Load," including voltmeter. Within a few days they understand that they have learned the entire system of wiring. The saving in the teacher's time "to inspect connections" is considerable. Above all, they learn that there is not one way to wire up a motor, and another way a lamp-board—all are connected up by the same system of wiring.

By the use of the board we have eliminated practically all meter injuries.

THERMOMETRIC LAG AND A METHOD FOR ITS MEASUREMENT.

By Richard Edwin Lee, Sc. D.,
Professor of Chemistry, Allegheny College, Allegheny, Pa.

Introduction.

The mercury-in-glass thermometer is the almost universal laboratory instrument for the measurement of temperature. Owing to the intimate relation between the properties of a substance and its temperature this instrument is surpassed in usefulness by very few if any other instrument found in physical and chemical laboratories. Its importance in the domain of science is attested by the voluminous literature relating to its development and accurate use. The training of a physicist or a chemist can scarcely be regarded as complete if it has not enabled him to use the Hg-in-glass thermometer with precision. The science of thermometry, therefore, has come to hold a position of fundamental importance.

This type of instrument depends, as is perfectly well known, upon observations of the relative expansion of mercury and glass. The properties of glass are such, however, that if the bulb of a thermometer having been exposed to a given temperature, either high or low, is transferred to an environment differing considerably in temperature it does not immediately undergo all the *possible change*—either expansion or contraction. It is true that the greater part of the possible change occurs very quickly but there are small *residual changes* which proceed very slowly over a period of hours, days or weeks. This "lagging" of the thermometer is known as "thermal hysteresis" and is not to be confused with "thermometric lag" the subject of discussion in this paper. The former manifests itself in the so-called "elevation," "depression," and "recovery" of the zero point. The magnitude of these phenomena depends mainly upon the nature of the glass and the differences in temperature to which the thermometer has been exposed.

It is obvious, therefore, that on account of these phenomena of thermal hysteresis that the observed "reading" of a thermometer depends not alone on its temperature, but also on its previous thermal history, and that procedures for the elimination of errors form this source should be formulated.

An examination of a treatise on thermometry will reveal to the student, of course, that the foregoing phenomena are not the only sources of error attendant upon the use of the thermometer and

that carefully defined procedures, tables of corrections and equations have been formulated to minimize errors from the sources indicated. As pointed out previously, it is essential that the student undertaking scientific work should be familiar with this data, and if his laboratory assignments have been sufficiently comprehensive he will have applied to his thermometric observations at some time or another all of the following corrections.

TABLE OF CORRECTIONS FOR HG-IN-GLASS THERMOMETERS.

(Primary Standards.)

1. Corrections for Irregularities in Graduation.
   - A. Correction of "fundamental interval."
     - a. Location of "ice-point" (O C). Changes of the ice-point. Temporary and permanent.
     - b. Location of "boiling-point."
   - B. Determination of the relation of the internal volume of the stem to the scale which has been provided.
     - a. By calibration of the stem between fixed points.
2. Correction for the effects of variation in the internal pressure. (Due to changes in the height of the mercury column, vapor pressure and capillarity.)
3. Correction for the effects of variation in the external pressure.
   - a. Determination of the effect of variation in the barometric pressure.
   - b. Determination of the effect of variation in depth to which thermometer may be immersed in a liquid.
4. Correction for emergent stem.
5. Correction for "thermometric lag."
6. Corrections for reduction to standard scales.
   - a. Corrections for "Hydrogen Scale" (100°C. to lowest attainable temperatures).
   - b. Corrections for "Nitrogen Scale" (100°C. to approximately 1600°C.).
   - c. Corrections for reduction of actual gas scales to "Thermodynamic Scale" (Ideal gas scale).

Of all the corrections listed in the foregoing table, the one designated as "thermometric lag" has been without doubt the most difficult of comprehension and application for the students doing work in thermometry and calorimetry in this laboratory. It was this experience which led the author originally to prepare the following "notes" for his students and it is at their suggestion that they are submitted for publication.

The discussion and determination of "thermometric lag" as outlined here do not possess the rigorous accuracy which is characteristic of the severely mathematical treatment accorded the subject by Thiesen[1], Guillaume[2], Harper[3] and others; but it is believed that any departure is easily within the allowable limit of error and it is hoped that a treatment "put lightly like powder in jam" may eventually encourage the student to take more heroic doses.

[1]Thiesen, *Metronomische Beitrage*, No. 3, page 13 (1881).
[2]Guillaume, *Thermometrie de Precision*, page 184 (1889).
[3]Harper, D. R., *Thermometric Lag*, Bur. of Standards, Rep. No. 185.

Determination of the Lag of a Thermometer.

When a thermometer is immersed in a warmer or cooler medium, or in one of which the temperature is changing, for the purpose of ascertaining the temperature of said medium it does not immediately indicate the true temperature of the latter, but lags behind both in point of *time* and *degrees*.

For example, if a thermometer be plunged into a bath maintained at a constant temperature (it being assumed that the thermometer was initially at a different temperature) a certain time must elapse before the temperature indicated by the thermometer will agree with the temperature of the bath. The thermometer readings are thus said to "lag" behind the true temperature (of the bath) by an amount which depends upon the construction of the thermometer.[4]

The interval of time which must elapse between the time of a given "reading" and the time when the thermometer indicates the (true) temperature of the bath is known as the "time lag". or

The difference (expressed in degrees) between the temperature indicated by the thermometer at a given time and the final temperature when the thermometer is in thermal equilibrium with the bath is known as the "degree lag."

In the case of a thermometer immersed in a bath the temperature of which is changing uniformly the "degree lag" at any observation may be defined as the difference in degrees between the temperature indicated at the time of the observation and the true temperature of the bath. Such conditions are reproduced fairly well in ordinary calorimetric determinations.

In reply to the question, "How is the true temperature of the bath at time of any observation of the thermometer to be determined if the thermometer is 'lagging,' " it may be answered briefly here that *it is calculated from data* (previously secured by experimenting with the thermometer) *associated with the rate at which the thermometer is changing its temperature indications.*

Practically all theoretical treatment of the question of "thermometric lag" (i. e., the transfer of heat between a thermometer bulb and the medium in which it is immersed) is based on the assumption that "Newton's Law of Cooling"—namely, "the rate of heat transfer between two bodies is directly proportional to the difference of temperature between the two," holds for the thermometer.

[4]The magnitude of the "lag" is dependent not only upon the construction of the bulb, but also upon the medium in which it is immersed, the rate of stirring and the conditions of immersion. For example, it has been shown that the "lag" in the air of a room is 50 times that of the same thermometer immersed in a well-stirred water bath.—See Circ., B. of S., No. 8.

In other words, the rate of change in temperature indicated by a thermometer is proportional to the difference between the temperature of the thermometer and the temperature of the medium in which it is immersed.

From the foregoing it is at once concluded that the "lag" represents the difference between the temperature of the thermometer and the medium and that it is this difference in temperature (other conditions being kept constant) which determines the rate of change indicated by the thermometer. We would conclude also that there is a definite "lag" associated with each and every rate of change indicated by the thermometer, and that if these relationships had been established for a thermometer by experiment, we should be able at any future time when using this thermometer under the same conditions to calculate the "lag" by merely determining the rate at which the thermometer reading is changing. As a matter of fact, this represents the basis of theory underlying the method for correcting for thermometric lag.

We have now to consider the experimental method by which the relationship just pointed out, namely, between the "lag" and the rate of change in thermometer indications, may be established quantitatively. This is outlined in the following section of the paper.

Experimental Part.

The procedure for determining the "lag" of a thermometer under defined conditions is comparatively simple. The experimental study of "thermometric lags" of importance in applied thermometry and calorimetry involve the formulation of equations for but two sets of conditions: (1) The case of a medium at a constant temperature, and (2) The case of a medium with a uniformly changing temperature.

The Case of a Medium at a Constant Temperature.—In this case we have for our problem the investigation of the "lag" behavior of a certain thermometer, it being conditioned that the instrument is to be plunged into a bath maintained at a constant temperature, the thermometer being initially at a different temperature. Of course it is understood that if the thermometer reading be taken at a sufficient interval of time after introducing the instrument into the bath no correction for "lag" need be made but if this thermometer is to be used at any future time to determine the temperature of baths under similar conditions and the temperatures of these baths be required while the thermometer readings are changing, i. e., before it reaches the "equilibrium

state," it is obvious that the "degree lags" of the instrument at various rates of cooling must have been determined previously by experiments similar to those which have been outlined as follows in (a) and (b).

(A) THE DETERMINATION OF THE (DEGREE) LAG OF A THERMOMETER WHEN ITS TEMPERATURE IS FALLING.

Arrange a water-bath which can be well stirred and maintained at a constant temperature, for example, a calorimeter filled with water at the same temperature as the jacket and the room. Warm the thermometer until it indicates a temperature 2 or 3 degrees higher than that of the bath, then introduce it into the latter and quickly clamp it in position. Keep the water well stirred and take the reading of the thermometer every 10 or 15 seconds until the readings become constant. Be sure to keep the thermometer jarred by gently tapping it.

Plot the readings against the time and obtain the "cooling curve," such as ABC, Fig. 1. Then subtract each reading from the one preceding it. These values obtained (expressed in degrees) represent the rate of cooling for each succeeding interval of time. Now subtract from each reading of the thermometer the final temperature indicated by the instrument when it has reached its "equilibrium state." These differences (expressed in degrees) represent the "lags" exhibited by the thermometer at the given time intervals of the readings, or better, they represent the "lags" exhibited by the thermometer at its different rates of cooling.

The tabulation of this data will show at once that for each definite rate of cooling shown by the thermometer there is exhibited a definite "lag"—the theory being that whenever this thermometer is used under similar conditions and shows one of these definite rates of cooling, dr/dt, that its lag will be approximately the same as the one associated with that rate of cooling in the experiment just performed. Hence, if the observer knows the rate of cooling of the thermometer he can by referring to his table of data or diagram determine the lag of his thermometer at that time. By subtracting this "lag" from the last reading he noted when determining the rate of cooling he is able to compute the temperature of the bath without waiting for the thermometer to arrive at its "equilibrium state."

As an illustration of the method outlined, the following example has been added.

TABULATED DATA FROM EXPERIMENT.

(Bath has a constant T. of 20.000°C which corresponds to 1.020°C on Beckmann thermometer.)

No. of observation.	Time in secs.	Reading on Beckmann.	Rate of colling.	Lag in degrees.
1	0	2.850°C	?	?
2	15	1.145	1.705°C	.125°C
3	30	1.070	.075	.050
4	45	1.047	.023	.027
5	60	1.031	.016	.011
6	75	1.025	.006	.005*
7	90	1.022	.003	.002
8	105	1.021	.001	.001
9	120	1.020	.001	.000
10	135	1.020	.000	.000

*Lag when the rate of cooling is .006° per 15 sec.

Discussion of Figure: Tangents to the curve ABC show the rates at which the thermometer readings are changing and the angle θ determines the direction and, therefore, the point of contact of any tangent with the cooling curve ABC; for we have seen that the difference in thermometer readings (dr) divided by the corresponding difference in time (dt) of said readings, i. e., dr/dt, represents the rate at which the thermometer is

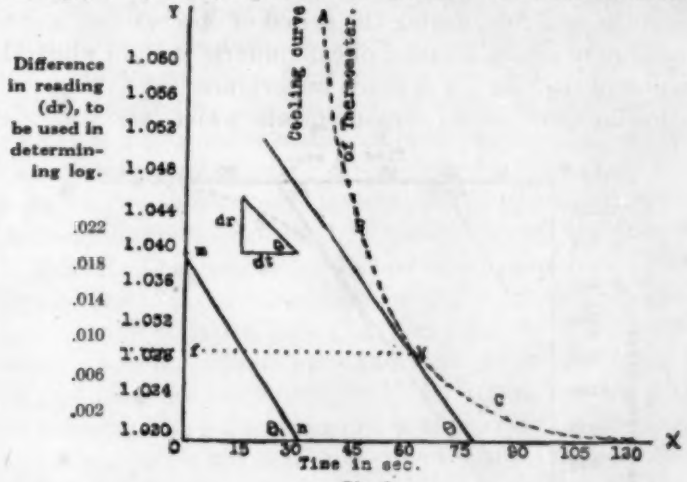


Fig. 1.

cooling, but this same value, dr/dt, is also equal to tan θ. Hence, if we draw a tangent to the curve ABC of thermometric readings at the point k, the *rate* at which the thermometer is cooling is equal to dr/dt and if θ is the angle the tangent makes with OX, the axis of time, then

$$\frac{dr}{dt} = \tan \theta$$

Therefore, if we draw a line, fk, from the point k to the axis of thermometer readings, parallel to the axis of time, it follows that the line fo (expressed in degrees) must represent how far the thermometer is from its "equilibrium state," i .e., its "lag" when the thermometer readings are changing at a rate represented by tan θ.

Problem.—Suppose it is required to find the lag when the readings on the thermometer is changing at the rate of .020°C. in 30 seconds (.010°C. in 15 sec.). Take a point m on OY, Fig. 1., equal to .020°C. and another point n on OX equal to 30 sec., then join the two points by the straight line mn. Now draw a tangent, to cooling curve ABC, parallel to mn. Tan θ is equal to the rate of cooling. From the point k where the tangent touches the curve ABC draw the line fk as directed above. Evaluate in degrees the line fO, and it will be found that the lag is approximately .009°C.

(B) THE DETERMINATION OF THE LAG OF A THERMOMETER WHEN ITS TEMPERATURE IS RISING.

Arrange apparatus as outlined in (a). In this case, however, cool the thermometer until it indicates a temperature 2 or 3 degrees lower than that of the bath, then suspend it in the latter, make observations and record data as indicated in (a).

The graphic representation in this case (See Fig. 2.) will differ a little from that of (a) but the theory of it is identical.

[5]NOTE.—"Because of the sticking of the meniscus and possible separation of the Hg column, the readings of a Hg thermometer with falling temperatures are less reliable than with rising ones, and in precision thermometry a falling temperature should be avoided whenever possible. When its use is unavoidable the difficulties are overcome to a considerable extent, in the case of a small rate of fall, by subjecting the thermometer to a series of rapid jars, as by an electric buzzer." B. of Standards, Reprint No. 185.

The Case of a Medium with a Uniformly Changing Temperature. —Although this case requires for its comprehensive treatment the formulation of equations for the determination of lags of thermometers located in baths which do not attain to a constant temperature, as a rule, during the period of observation, it is restricted here to a consideration of calorimetric work in which the evaluation of the "lag" is of much importance.

In precise calorimetric measurements which are now very

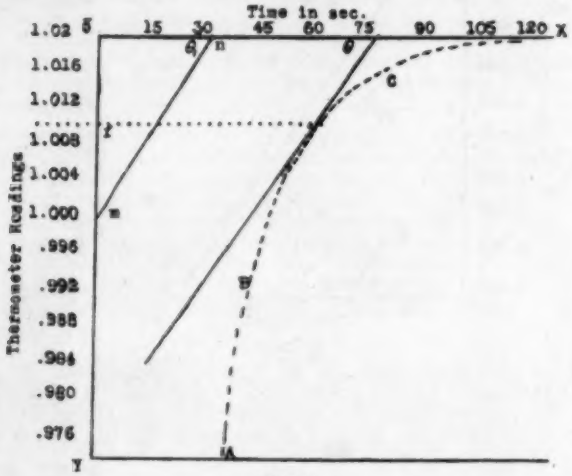


Fig. 2.

generally conducted in "adiabatic" calorimeters in which case, of course, no correction need be made for loss of heat by radiation (and conduction), the procedure consists merely in determining the total change of temperature of the contents of the calorimeter by observing the initial temperature of the system and the final temperature of the same at which points the thermometer readings are practically constant. The method for correcting for the "lag" under these conditions has been considered and need not be applied again.

In the case of calorimetric measurements carried out in non-adiabatic calorimeters, however, the conditions under which the thermometer exhibits "lag" differ somewhat from those specified in the first case. This is due to the fact that a correction must be made for the loss of heat by radiation. The method employed in determining the magnitude of the correction to be applied for radiation effects determines the *modus operandi* in determining and applying the correction for "thermometric lag." Therefore, let us consider briefly this problem.

Thermometric Lag in Relation to Regnault's Method for Correcting for Radiation Effects.

The two methods most frequently employed in correcting for radiation effects in calorimetric work are Rumford's Method and Regnault's Method. By the first method an effort is made to eliminate by experimental procedure the necessity for introducing a correction factor for radiation effects into the calculation of the final data. The method, however, is not entirely satisfactory and Regnault's method is to be regarded as the preferable one of the two methods.

Regnault's Method.—This method provides for the measurement of the loss of heat by radiation and the introduction of a "correction factor" for same. The evaluation of this "correction factor" is accomplished by the experimental determination of the "radiation factor" of the calorimeter at an observed temperature for definite period of time, from which may be calculated the "radiation quantities" for the successive periods of time during which the temperature of the calorimeter was rising. These quantities are then added to the maximum temperature recorded.

Regnault's method as originally formulated was unsatisfactory in that it assumed that the temperature of the thermometer followed exactly the temperature of the contents of the calorimeter. This we have seen is not the case and that a correction must be applied for the "lag." This may be done as follows: Having ascertained the "lag" behavior of the thermometer under conditions similar to those of the experiment contemplated proceed according to Regnault's method but note with care the final temperature (falling) observed. Obviously the last radiation quantity recorded represents the rate of cooling of the thermometer. Calculate the "lag" of the thermometer, subtract it from the final reading, then add all of the radiation quantities for the various periods of the experiment. The result thus obtained will represent the highest temperature which the thermometer would have recorded during the experiment had there been no loss of heat from the calorimeter by radiation and if the thermometer had not exhibited that which has been described in this paper as "thermometric lag."

Summary.

"Thermometric lag" has been defined in terms of both "time" and "degrees."

It has been accorded a theoretical treatment from the standpoint of "Newton's Law of Cooling."

A comparatively simple method by which a severely mathematical treatment has been avoided, has been outlined for the determination of the "lag" of a thermometer under various conditions.

The method of combining the correction for "lag" with Regnault's method for correction for loss of heat by radiation in calorimetric measurements has been presented.

A LABORATORY EXERCISE ON HEAT CONDUCTIVITY.

By Frederick A. Osborn,

University of Washington, Seattle.

The conductivity of various substances plays a rather important part in the daily life of everyone, yet a simple and satisfactory laboratory experiment to measure it, does not seem to have been described.

The apparatus described here was developed for a course in physics given to students of home economics. It is so simple and the operations are so easy that there is no reason why girls in high schools should not be given such an exercise.

The conductivity of a substance is proportional to its area, to the difference in temperature between the two faces, to the time, and inversely proportional to the thickness of the substance. We may write

$$\text{Heat} = \frac{k \times \text{Area} \times (t\text{-}t') \times \text{time}}{\text{thickness}}$$

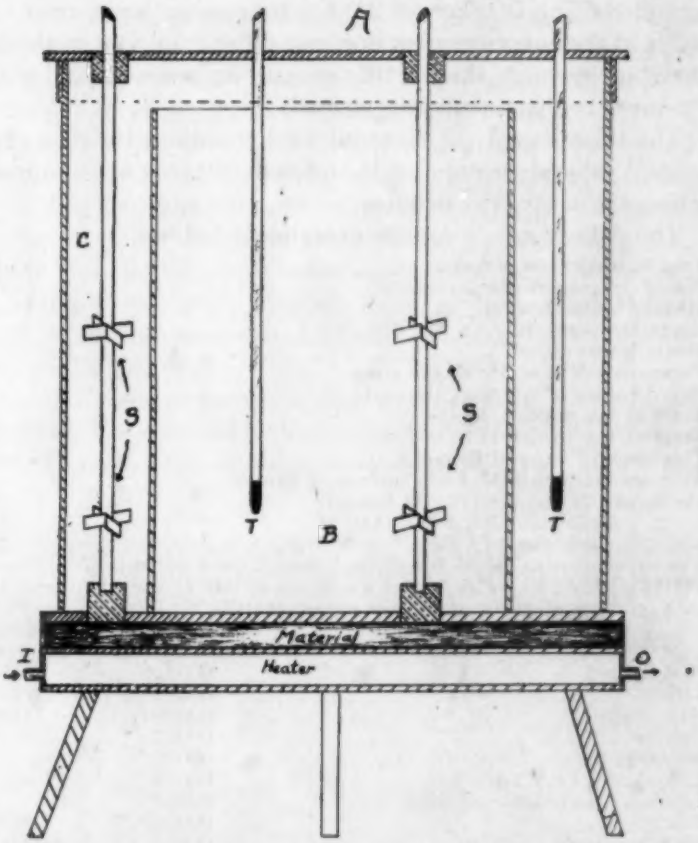
If H is to be expressed in calories, then the area must be given in square centimeters, $(t-t')$ in degrees Centigrade, time in seconds and thickness in centimeters.

Then

$$k = \frac{\text{H} \times \text{thickness}}{\text{Area} \times (t-t') \times \text{time}} = \text{coefficient of conductivity.}$$

The calorimeter, Fig. 1., consists of a double walled vessel A with a heavy copper bottom, 4 mm. thick, projecting 0.5 cm. beyond the walls. The diameter of the bottom is 16 cm. The areas of the two cylinders, B and C, are the same. A cover has openings for two stirrers, one in each compartment and for two thermometers.

The heater consists of a cylinder 15 cm. in diameter and about one centimeter thick. The upper face of the heater is made of the same heavy copper used in the calorimeter. Two 0.5 cm



tubes project from opposite sides of the heater, for the inlet and outlet of the steam which is furnished by the usual type of boiler found in laboratories.

When the calorimeter was made the weights of the copper bottom and of the walls of the inner cylinder were obtained. These, with the weight of the stirrer and the specific heats of the materials used, furnish the water equivalent or heat capacity of the inner compartment.

The method of operation is as follows. Five hundred grams of water 5° or 6° below the room temperature are put into each compartment, the substance to be tested is placed on the heater and the calorimeter is set on it. Steam is admitted into the heater

and the stirrers started. If the room temperature is 20° C., the first reading of the temperature in the inner compartment is taken when the temperature is 17° C., the time being noted. The second reading is taken at 23° C., time again being read. The water in the outer chamber does not differ from that in the inner chamber by more than 1/10° so gain or loss of heat by it to the inner compartment is neglected.

The thickness of the material used is obtained with a vernier caliper, several readings with different degrees of compression, giving the probable thickness.

The data from a complete experiment follows:

Area of inner compartment	79.25 sq. cm.
Water equivalent of calorimeter	26.25 grams
Mass of water heated	500 grams
Room temperature	20° C.
Steam temperature	100° C.
Temperature of water at the start	17°
Temperature of water at the end	23°
Time at the start, 1-30-45 Time at the end, 1-44.01	738 seconds
Thickness of dry red flannel	.196 cm.
Average temperature of top surface of flannel	20°

Coefficient of conductivity of flannel:

$$\frac{556.25 \times 6 \times .196}{79.25 \times 80 \times 738} = .000129$$

The experimental values for the red flannel used generally come between .00011 and .00015. The flannel was dried at 100° C. for 20 minutes before each test. Undried flannel gave about .00017.

	Coefficient of Conductivity	
	Laboratory results	Table values
Red flannel	.000129	.00013
Linen	.00022	.00021
Silk, white	.000090	.000095
Cotton	.00023	
Brussels carpet	.00022	
Linoleum, new	.00046	
Linoleum, old, different make	.00049	
Felt	.000080	.000087
Blotting paper	.00017	.00015
Sawdust		.00012

GROUND-WATER RESOURCES OF THE UNITED STATES.

Bibliography Issued by the Geological Survey.

The United States Geological Survey, Department of the Interior, has just issued a bibliography and index of its publications on ground water and related subjects, such as windmills, pumps, and other lifting devices, methods of water analysis, and methods of measuring the flow of water.

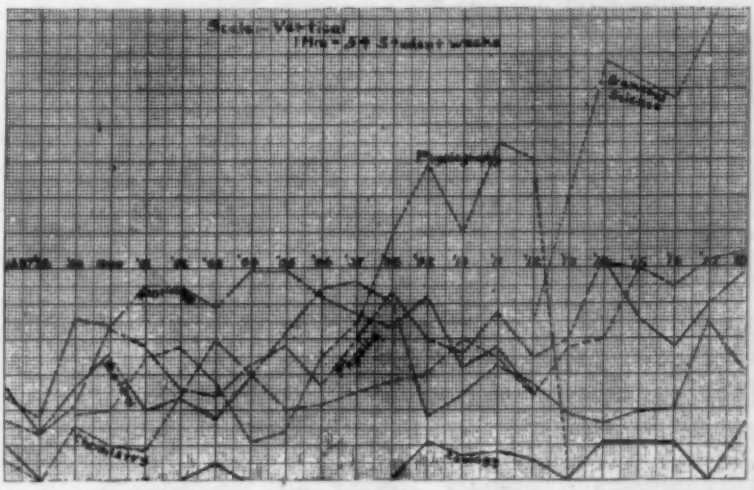
The Geological Survey's hydrologic investigations include work on both surface and ground water, but this bibliography, as its title indicates, covers only the Survey's reports on ground water. The bibliography lists more than 600 papers, of which more than 300 relate primarily to the subject of ground water. It contains brief abstracts of most of the reports listed. A detailed index of over 100 pages constitutes the larger part of the pamphlet, which contains also a map of the United States showing the area covered by each report.

SCIENCE ENROLLMENT AT ELGIN HIGH SCHOOL.

VILLA B. SMITH,
High School, Elgin, Ill.

The accompanying graphs, compiled from data on file at Elgin High School, furnish the history of five departments in that institution during the past twenty-two years. The enrollment is expressed in terms of student weeks; that is, if a class of twenty students carries a subject for twenty weeks, the enrollment is considered four-hundred student weeks. In this way it is possible to make comparisons of subjects running each semester with those running the entire year without flagrant error.

All the departments show increased enrollment due to the natural growth of the school. English, however, made greatest progress, changing from second rank in 1897 to first in 1905 and maintaining that place since. Science held fourth place in 1897 and in the years following proved a close competitor with mathematics. In 1917 it outranked mathematics and 1918 found it ranking next to English, and showing every tendency for further advance.

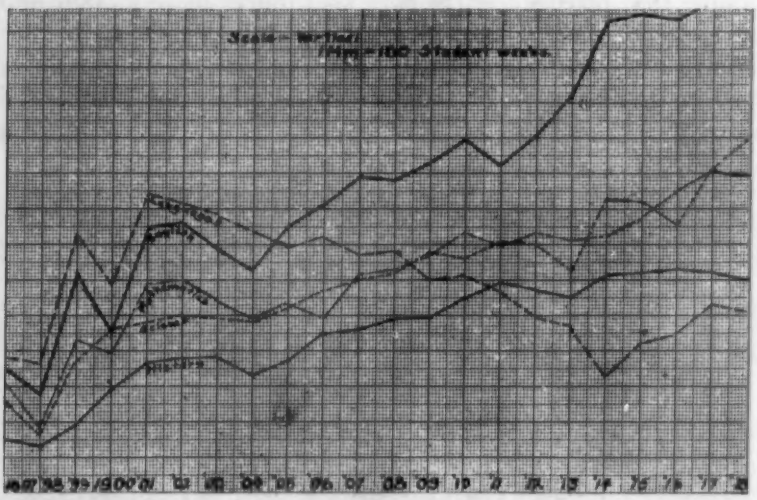


The languages were leaders in 1897 and maintained their place until 1905, then showed a marked decline until 1914, since which time there has been a feeble advance, not sufficient, however, to lift them from the place of lowest rank. History has shown the most uniform growth, and for the past five years has been practically the same.

For this twenty-two year period the individual sciences have

had an interesting history. Physiology led in 1897, followed by botany, physics, zoology and chemistry. In 1899 physiography was introduced, and for the years 1907-1912 had the greatest enrollment. In 1913 it dropped from the curriculum as a year study; 1912 marked the disappearance of physiology as a semester study.

In 1912 general science was introduced and 1918 found it with an enrollment but fifty less than that of all the other sciences combined. This general science, however, consists of twelve weeks of physiology and twenty-four of modern geography, so represents no new subject matter. That physiology, physiography and general science have been the leaders is entirely due to the fact that they have been the required first-year sciences.



Chemistry enrollment has shown a steady increase, outranking that of physics for the four-year period 1915-1918. At present physics and chemistry are both required for graduation from the four-year science course. The English, general, foreign language and four-year household arts courses require either physics or chemistry, while the manual training course requires physics. As the majority graduate from the general course the choice between chemistry and physics accounts for their popularity.

Botany and zoology are required in both the science and four-year household arts course, while botany is included among the requirements for the two-year household arts course. For

the general course, however, with the greatest enrollment, the biological sciences are elective. That in part accounts for their low place among the sciences. Still, should the combined enrollment in botany and zoology be considered, the life sciences rank well with both physics and chemistry. The fact that there are two to elect from, equalizes the enrollment.

In 1897 of the three courses offered by the school, two required one semester of botany and the third allowed a choice between one year of algebra and a semester each of physiology and botany. In 1900 all the courses required physiology as a first semester study and allowed a choice between botany and physical geography for the second. The 1903 requirements for graduation state specifically, "Students should elect before graduation one of the following: Physics, botany or zoology." In that year botany and zoology were presented as year courses. By 1906, however, botany and zoology are found among the second-year electives.

Domestic science was introduced in 1904 and since that time has had an average annual enrollment of sixty-eight. This course allowed another choice among electives. Its enrollment, however, has not been considered among data here presented.

The foregoing clearly shows that science is not on the decline in Elgin, it ranking well with English, which offers little elective work. Even though the science curriculum has been much enriched, from three and one-half years in 1897 to six in 1918, the consequent greater freedom of election has not caused a decline in any one science.

CRISIS IN THE AMERICAN POTASH INDUSTRY.

The present is a critical time for the potash industry recently established in the United States, according to H. S. Gale, of the U. S. Geological Survey, Department of the Interior. Prior to the war this country used more than a million tons (gross weight) of potash salts each year, and it has been supposed that the cutting off of a large part of this supply was a keen deprivation, particularly to the farmer, by whom it was used for fertilizer. This foreign supply has not been available during the war, and with much energy and enthusiasm a domestic production equivalent to about one-fourth the former importation has been built up. Now, however, it is unexpectedly disclosed that there is little or no market for potash either at the high prices that have prevailed or even at a considerably lower price. No satisfactory explanation of this situation seems to be offered.

Approximately 100,000 tons (gross weight) of potash salts, produced in Nebraska in 1918, are reported as lying in storage warehouses, distributed throughout the southeastern States, which is the region where potash is principally consumed. This is of the same quality that was used in 1917 and is immediately available to the fertilizer manufacturer or the farmer. Potash of other sorts from various sources is also reported unsold.

AN ANALYSIS OF SOME ADVERTISEMENTS.

By H. K. Rhodes,
High School, Chambersburg, Pa.

Some months ago while reading the Literary Digest my attention was attracted to a full-page advertisement of a well-known lubricating oil. In the main, it was an exposition and explanation of four tests to which this oil is put before being placed on the market. These tests were for viscosity, specific gravity, flash-point, and sedimentation. My interest was aroused because these terms had been sometime previously discussed and worked out in my classroom. Furthermore, I became curious to know whether there were other advertisements of like nature. I looked through the advertising pages of two copies of The Saturday Evening Post (Feb. and May 4, 1918) and a copy of The Literary Digest (May 25).

In these three numbers thirty advertisements were found which set before the public at least twenty-five different articles, manufactured by reputable firms, including piston rings, metals for building trusses, insulation for pipes, auto lenses, soups, ball bearings, furnaces, tires, tooth paste, wire fabric, electric devices for the home, razors, fuses, breakfast food, lubricating oil, incandescent lamps. One of the Post ads was a two-page, the remainder were divided about equally between half-page and one-page; two used blueprints; two used graphs and curves; several showed statistics in tabular form; one used cuts of the water bath, Bunsen burner and tripod, hydrometer and jar, and the centrifuge; one made use of a formula $V^2/10.8$ and explained its application to the speed of automobiles; one, by Westinghouse, was illustrated by fine, large pictures of turbo-generators, transformers, and meters—much better cuts than to be seen in many textbooks. A number emphasized the "scientific accuracy" derived by "scientific tests" in laboratories (words in quotation used in the ads). One, by the Champion Spark Plug Co., stated that 3,450 experiments had been made to develop a porcelain suitable for the gas engine.

The terminology of the ads is scientific, in some cases very technical. The following list of 58 words taken from the 30 ads is significant—expansion, insulation, lenses, watts, efficiency, galvanized, electrically welded, acids, salts, alkali, turbo-generator, transformer, wattmeter, microscopic, fuses, overload, viscosity, specific gravity, hydrometer, centrifuge, flash-test,

sedimentation, held in suspension, organic, friction, diffusion, refraction, horsepower, elasticity, buoyant, magneto, conductivity (heat), graph, prism, litmus, electrical resistance, oxygen, nitrogen-filled, focus, combustion, humidity, vitreous, vitamines, food-values, dietary, field of vision, tensile strength, balanced diet, leverage, centrifugal, distillate, diaphragm, alternating current, direct current, factor, hydraulic, compressed, storage battery, pulley. The list reads like an index page in a physics text and indicates the tone and character of the ads.

Since last May I have carefully examined the advertising pages not only of the Post and of the Digest, but of other magazines of the better grade; also I have compared the advertising matter of today with that of some years ago. Evidently there has been a change in methods. Today there seems to be a growing tendency on the part of manufacturers to inform the public not only of the excellence of their products, but to show how and why they are good; that by scientific accuracy, tests and research this high standard of quality has been attained. This is not only true for mechanical devices but for many other commodities where science can at all be applied.

Two causes may be given for this tendency—competition and an educated public. It is a fact that manufacturers and merchants more than ever before are putting their business on a systematic basis, and wherever possible use scientific methods, employ chemists and other engineers, and establish laboratories in order to reduce costs and to make better products. But for them to employ the same ideas in their advertising seems odd. Will the public read such advertising matter? It is true that some of the articles advertised interest only a few, yet the majority of those commodities are desired and used by many. Advertising managers would not employ this type of appeal if it did not pay; if they were not certain it would be read and appreciated.

That the public can be interested by this form of advertisement, I believe for this reason: It is an educated public, especially in science. Science has come to play a great part in our lives; it touches every one—in the home, in the shop, in the store, on the farm. The desire for more comforts and conveniences, for better things in general, has brought about higher standards of living. Many things that were luxuries have become necessities. Our schools have helped all classes by offering courses in agriculture, biology, domestic science, manual training, phy-

sics, chemistry, etc. In the home one uses many devices about which one must have at least a fundamental knowledge of science for their successful operation, repair, and renewal. For the farmer the daily delivery of mail, the telephone, and the automobile have done much to raise his standard of living. He no longer is isolated and his children may receive an education as good as that of children of the city.

The study of science branches is started early in the grades, especially nature study, physiology, hygiene, and general science. There are very few of the younger generation today who have not had some science training. It follows, then, that the public should be able to read with understanding the type of advertising discussed in this article; and secondly, that the type reflects, in a measure, the thought and life of today.

Another phase of this matter may be suggestive and of interest to some. Reference has been made to the excellent pictures in some of the ads. I have made much use of them in opaque projection. For instance, as a review in physics nothing serves better than to study the automobile to illustrate the application of principles in mechanics, heat, electricity, and light. The cuts from ads and catalogs thrown on the screen are very valuable for their aid in holding the interest of the pupils.

SHELLS THAT REVEAL THE AGE OF ROCKS.

The little jelly-like animals which the scientist calls Foraminifera swarm so abundantly in the sea that their tiny cast-off shells in some places make up a considerable part of the sediments which are laid down on the sea bottom and which in time may become beds of rock in a land area. The small size and the compactness of these shells protect them from some of the accidents that befall the remains of larger animals, so that in many samples of well borings the Foraminifera are the only shells that have survived in recognizable form the vicissitudes of drilling. In the hands of specialists trained to identify fossils the Foraminifera may furnish the only available clue to the age of the rock inclosing them and consequently to the existence of strata or structure favorable or unfavorable to the accumulation of oil, gas, or water. Thus the "spectacled scientist," who may really look like an alert business man, becomes the helpful adviser of the "practical" oil geologist or the well driller.

The United States Geological Survey, Department of the Interior, has recently issued a report that may be of great value in the search for underground water, oil, and gas. This report, prepared by Joseph A. Cushman and issued as Survey Bulletin 676, contains descriptions of some species of Foraminifera from the Miocene and Pliocene formations of the Coastal Plain of the United States and is abundantly illustrated with figures, many times magnified, of these minute organisms.

A copy of Bulletin 676, which is purely technical, may be obtained without cost by applying to the Director of the United States Geological Survey, Washington, D. C.

THE VENTILATION OF CHEMICAL LABORATORIES.

By F. H. Wiese,
Kewaunee, Wis.

In the planning and erection of the modern school building possibly no one feature is more carefully considered than the proper ventilation of the building, and yet I venture to say that very little attention is paid to this question, that is so important to the health and comfort of the students, after the building is complete and the chemical laboratory is in operation.

The architect will work out a very elaborate system of ventilating that, under expert management, will change all the air in the entire building every few minutes.

This costly equipment will be in charge of the janitor after the building is in operation—the janitor who possibly doesn't know, as no effort has been made to teach him, the principle upon which the ventilation system works.

After the building is complete the chemist will select the laboratory furniture, consisting of students' chemistry desks, hoods, etc., to efficiently conduct the various experiments that go to make up the laboratory work.

The students' chemistry desks are very often fitted with individual down draft hoods. These hoods are connected to a power electric fan. The rapid movement of air necessary to exhaust obnoxious fumes being generated by the classes in chemistry will necessarily retard and change the entire working of the ventilating system of the building.

It is impossible to build an open hood that will adequately exhaust obnoxious fumes, especially fumes and gases that are heavier than air.

The only type of chemical hood that will absolutely prevent the spread of mysterious smells and the distribution of obnoxious fumes through the entire building, when our future wizards of chemistry are concocting disturbances, is the closed kind, the hood that is absolutely airtight.

A closed hood connected to an air flue of ample size with a good chimney draft will usually work very satisfactorily, even in disposing of gases heavier than air, without the aid of an electric exhaust fan.

A closed hood when connected to a fan in operation, being practically airtight, will not affect the working of the building ventilating system, the proper functioning of which is so essential to the health and comfort of the students.

Even the hood attached to the instructor's desk may be the closed type. A small square hood without a bottom, to set over an opening in the top of the instructor's desk, this opening to be connected to a fan or strong chimney draft, by galvanized iron piping, will do the work well. The hood can be fitted with a sliding up, or swinging airtight door. When the hood is closed and the draft is on, no movement of air in the room is perceptible. The necessary suction in the hood will not be great enough to affect the ventilating system.

When a battery of hoods are to be fitted with an exhaust blower, ascertain the volume of the whole interior of the hoods in cubic feet, and attach a direct connected electrical fan with a capacity of 2 1-2 times the total volume. This will result in exhausting the air of the equipment twice in one minute, allowing twenty per cent for friction loss.

If the exhaust is attached to a chimney flue, with a good draft, a fan with a capacity of seventy-five per cent of the total volume will give excellent results.

Of course the distance from the hoods to the inlet in the chimney must be considered. For every ten feet of piping add ten per cent to the fan capacity, also add ten per cent for every 90° turn in the pipe. The above figures and estimates are based upon actual experience and practical tests.

VICTORY LIBERTY LOAN.

An interesting announcement from Washington, in connection with the coming Victory Liberty Loan campaign, is that the workers in the Victory drive will be awarded medals made from captured German cannon.

An official message to this effect was received from the Treasury Department by Ben F. McCutcheon, Publicity Director of the Liberty Loan Organization, Seventh Federal Reserve District, the text of which follows:

"You are at liberty to make full use of the announcement that the Treasury Department will award medals made from captured German cannon to all workers during the Victory Liberty Loan campaign. The medal is the size of a half dollar and contains on one side a reproduction of the Treasury building and on the transverse side a certification of Loan participation. Space is left for engraving the name of the recipient."

"I heartily approve of this action of the Government in casting up honor medals made from German cannon to award to Victory Liberty Loan workers," said Charles H. Schweppe, Director of Campaign for the Seventh Federal Reserve District. "It supplies an added incentive to supreme endeavor and surely will have a good effect that will be shown in increased sales. The awarding of these medals made from cannon captured from the foe should result in bringing us a full complement of workers."

HISTORY OF MATHEMATICS AT UNIVERSITY OF CALIFORNIA.

By Oscar Schmiedel.

The Univeristy of California has recently inaugurated a new department in creating a chair for the History of Mathematics.

One given to polemics might take this for an answer in advance to a question which seems to have occurred to some, and which was asked in an editorial of a students' publication of the university in the form: "Shall we abolish the university, or shall we let it hibernate?" The implied charge being that the great institution has failed to keep in sufficiently close touch with the tendency of today toward the practical.

It is indeed befitting that the repository of the Bancroft library should seek to keep the spirit alive that breathes from those unique volumes, and should extend its scope into new fields that, though circumscribed, are fraught with peculiar promise of results.

Professor Florian Cajon enjoys the distinction of being the first appointee to the first chair of History of Mathematics established. As is to be expected from the spirit that pervades his writings, his lectures breathe, besides the atmosphere of learning emanating from the indispensable display of facts and figures, the liberal air of human sympathy and universal interest.

Three courses are given the first term of the present session; a largely attended course on The History of Mathematics and Physics, a course on The Teaching of Mathematics in Secondary Schools, and a most interesting seminar course on The History of Fundamental Concepts of the Calculus and of Fluxions.

USEFUL BENEFITS FROM STUDY OF MATHEMATICAL HISTORY.

By Oscar Schmiedel.

Of the many benefits from the thoughtful study of Mathematical history, not the least are the suggestions and inspirations from partly solved problems.

Thus, we read, the Pythagoreans found the sum of consecutive odd numbers to be a square number; as $4^2=1+3+5+7$. Later, that Nichomadus gave the important theorem that cubical numbers are sums of consecutive odd numbers; as $4^3=13+15+17+19$[1]. Nothing more is recorded.

The reading of these facts together suggests the question whether the fourth powers also are expressible as sums of consecutive odd numbers.

A little experimenting soon reveals the truth of the supposition; for, it is found that the following statements are true:

$1^4=1$,
$2^4=7+9$,
$3^4=25+27+29$,
$4^4=61+63+65+67$, etc.

With this discovery, the reader, if at all mathematically talented, will scarcely lay his pen aside before having in a similar manner investigated the fifth powers. And lo! these too are found expressible in this form, namely:

$1^5=1$,
$2^5=15+17$,
$3^5=79+81+83$,
$4^5=253+255+257+259$, etc.

Now it would seem strange that when the second, third fourth and fifth powers observe this simple relation, this should not also hold in the case of the sixth, seven and higher powers. Indeed, one feels convinced it must.

Comparison of the results so far obtained would indicate that if a^n *is* so expressible, the sum very probably will consist of a such terms. Calling the first term F_n, the sum would be:

(1) $a^n=F_n+F_n+2+F_n+3+\ldots+F_n+Z(a-1)$;
or, $=aF_n+a(a-1)$.

And hence:

(2) $F_n=a^{n-1}-a+1$.

Then, with this first term found, the sum may be written as in (1).

The statement (1) is an assumption; hence (2) may be taken as a definition of F_n. From this definition, after mutiplication by a, a^n is found as:

(3) $a^n=aF_n+a(a-1)$.

But the second member of (3) may always be written as a sum of a terms in the form (1); and F_n in it is an odd number, since $a^{n-1}-a$ in (2) is even whether a is even or odd.

Hence, our history reading has led us to the discovery of the interesting theorem that *Any power of an integer is expressible as a sum of consecutive odd numbers.*

By the theorem itself, this may also be stated in this form: Any power of an integer is expressible as a difference of two square numbers; even in a variety of ways, as $3^5=42^2-39^2$; $3^5=18^2-9^2$; the general form being;

(4) $$a^n=\left(\frac{a^{n-m}+a^m}{2}\right)-\left(\frac{a^{n-m}-a^m}{2}\right)^2$$

[1]Cajori, History of Mathematics, p 33.
Tropke, Geschichteder Elementar-Mathematik, II, 322.

BIOLOGICAL STATION, UNIVERSITY OF MICHIGAN.

The University of Michigan will maintain its biological station for the eleventh season, June 30 to August 22, 1919, on the shores of Douglas Lake, near Pellston, Michigan. Here within twenty miles of Petoskey, the center of the great playground of northern Michigan, instruction of university grade will be given in various biological subjects. The station is, however, so well isolated from the summer resort crowds that it does not suffer interruptions to its regular program of work while its members derive the full benefit of the fine climate of that region. Teachers, jaded from a hard year's work, are able to recuperate and yet gain six to eight hours of credit toward a baccalaureate or an advanced degree.

Courses giving credits are offered in entomology, ornithology, vertebrate zoology, ecology of invertebrate animals, systematic botany, plant ecology, and plant anatomy. Those who are qualified may carry on investigations independently or under direction. Other work not mentioned above but within the scope of the fauna and flora of the region and the means of the instructional staff to give instruction may be undertaken. A limited number of investigators from other institutions may secure the privileges of the station upon payment of nominal fees.

The teaching staff will include Professors La Rue, Welch, Gates, and Ehlers of the University of Michigan, Professor Smith of the University of Illinois, Professor Quick of De Pauw University and Mr. Dayton Stoner, Instructor in Zoology in the State University of Iowa.

For further information address George R. La Rue, Director of the Biological Station, University of Michigan, Ann Arbor, Michigan.

"SHARKING" OF LIBERTY BONDS BY "SHYLOCKS"

The "sharking" of Liberty bonds by "Shylocks" and the use of the advertising columns of the newspapers by promoters of wildcat stock concerns, offering to take Liberty bonds in return for securities palpably "insecure" and which came perilously near to being out-and-out swindling, aroused the newspaper owners and the Association of Commerce to united action to put a stop to the crooked practice and protect the holders of Liberty bonds who are animated by an impulse to get rich quick.

This movement should go a long way toward stamping out the swindling "financial pirate," who has been waxing fat off the incredulity of Liberty bond holders.

Prefacing their agreement to refuse advertising from individuals and firms engaged in the "sharking" of Liberty bonds with the statement that "hundreds of disreputable brokers are doing everything in their power to persuade the public to exchange its Liberty bonds for other securities, a great portion of which are worthless," the Chicago publishers announced the following rules, "to be used for hasty reference only, as a means of recognizing quickly the more obvious forms of objectionable copy," which also are submitted to the other publishers throughout the District:

(1) Never accept copy from a firm offering to exchange other securities or commodities for Liberty bonds.

(2) Never accept copy from a firm, even though it is recommending good securities, unless you have first investigated its standing.

(3) Do not accept copy that contains: (a) Extravagant statements; (b) prospective earnings directly compared with the earnings of old, established concerns; (c) suspicious use of such expressions as "absolutely safe," "best investment ever offered the American public," "immense profits on a small investment," "you take no chances," etc.; (d) guarantee

or promise of large dividends from future earnings because the earning power has been thoroughly demonstrated; (e) guarantee on the part of the broker to resell the stock at a higher price than it is selling for; (f) promises of an advance in the stock after a specific date.

(4) Do not accept copy concerning any unproved prospects and developments such as oil or mining securities, unless very carefully investigated and convinced of their positive merit.

(5) In case copy is received too short a time before requested insertion to permit of proper investigation, it should in all cases be held up pending investigation unless the proposition advertised is obviously reputable.

STUDIES OF RESERVOIR SITES IN COLORADO.

Geology May Determine Proper Sites.

A short report which shows very clearly how the value and effectiveness of certain engineering structures near the headwaters of the Rio Grande in the Rocky Mountains is dependent on geologic conditions or on the nature of geologic deposits has just been published by the United States Geological Survey, Department of the Interior, as Bulletin 685, entitled "Relations of Landslides and Glacial Deposits to Reservoir Sites," by W. W. Atwood. This report is a "by-product" of a general investigation of the glaciation and physical geography of the San Juan region, in southwestern Colorado.

A study of the landslides in this region was made several years ago by Ernest Howe, whose report was published by the United States Geological Survey as Professional Paper 67, entitled "Landslides in the San Juan Mountains, Colorado." Mr. Howe's report includes a classification of the landslides and a consideration of their causes and is fully illustrated with instructive views.

The author of the report just published, Mr. Atwood, sets forth the causes of the numerous natural reservoir sites in this region, some of which have already been utilized, and the nature of the materials at and around the sites. He shows that some sites which appear attractive are, in fact, unsafe and can never be made safe, and that others are wholly safe and satisfactory.

How the Geologist May Help the Engineer.

The report gives emphasis to the fact that a knowledge of geology or an appeal to the judgment of the geologist may at times be of great service to the engineer. It not only gives detailed descriptions and numerous views of reservoir sites, glacial moraines, and landslides but it shows how the moraines and landslides affect the efficiency of the engineering work done and sets forth general principles of wide application, and it should therefore be of practical value to engineers working in this or similar areas. The construction of dams, canals, tunnels, and reservoirs for the water supply of cities or of communities that depend upon irrigation is often not merely a question of sound and honest building. The best structure may collapse because its site was unwisely chosen. A great dam may be perfectly safe and quite water-tight, yet the reservoir behind it may never fill because of leakage at some place remote from the dam; or the dam itself may fail not because it is poorly constructed but because the walls of the valley which it closes are too weak or too pervious to resist the great force exerted by water under high pressure.

A Story of Land Sculpture.

The report contains a brief but clearly written story of the origin of the physical features of this attractive mountain region. It tells why the

valleys are open parks here and constricted canyons there; it explains the forms of the drainageways; it tells why the streams are at some places gentle brooks, meandering, willow-lined, through flower-dotted meadows and are at others wild rapids dashing along over boulder beds or through narrow canyons. It explains the great terraces that extend like railroad embankments along some of the valleys and the curved and hummocky ridges that cross them.

This brief paper will also be of value to teachers of geology who want a short summary of the glacial history of the upper Rio Grande basin, and it will be of interest to summer tourists who desire to gain some understanding of the origin of the things they see.

The report can be obtained from the Director of the United States Geological Survey, Washington, D. C.

ARTICLES IN CURRENT PERIODICALS.

American Botanist for February; *Joliet, Ill.; $1.25 per year. 35 cents a copy*: "Vinegar Bees," Willard N. Clote; "Fragrant Wildflowers," C. L. Gruber; "Money in Drug Plants," Willard N. Clote; "The Name Toxylon Agans," I. C. Nelson.

American Journal of Botany, for March. *Brooklyn Botanic Garden, Brooklyn, N. Y.; $5.00 per year, 60 cents a copy:* "The Ecologic Subterranean Anatomy of Some Plants of a Prairie Province in Central Iowa," Ada Hayden; "Studies Concerning the Evolutionary Status of Polycotyledony," John T. Buchholz; "The Role of Sedges in Some Colorado Plant Communities," Francis Ramaley.

American Mathematical Monthly, for March; *W. D. Cairns, 27 King Street, Oberlin, Ohio; $3.00 per year, 35 cents a copy:* "Third Annual Meeting of the Mathematical Association of America," W. D. Cairns; "On the Envelope of the Wallace Lines of an Inscribed Quadrangle," D. F. Barrow; "Geometric Explanation of a Certain Optical Phenomenon," W. H. Roever; "Concerning a Method for Finding a Particular Integral." Note on Professor Coble's Article, H. P. Manning.

Condor, for March-April; *Hollywood, California; $2.00 per year, 40 cents a copy:* "Nesting Notes on the Rocky Mountain Creeper" (with four photos), W. C. Bradbury; "Notes on the Breeding Habits of the Red Crossbill in the Okanagan Valley, British Columbia," J. A. Munro; "Notes on the Nesting of Two Little-known Species of Petrel," George Willett; "Bird Notes of a Stormy May in Colorado Springs" (with one photo), Edward R. Warren; "Losses Suffered by Breeding Birds in Southern California," H. Arden Edwards; "Bird Records from the Sacramento Valley, California," Alexander Wetmore; "Notes from the Feather River Country and Sierra Valley, California," Joseph Mailliard; "The Marital Tie in Birds," Loye Holmes Miller; "The Summer Birds of Hazelton, British Columbia" (with one photo), P. A. Taverner.

Geographical Review, for March; *Broadway at 156th St., New York City; $5.00 per year, 50 cents a copy:* "The Regions of Mixed Populations in Northern Italy" (one insert map in color), Olinto Marinelli; "High-Altitude Flying in Relation to Exploration," Henry Woodhouse; "Raised Bogs in Eastern Maine," George E. Nichols; "The Circumference of Geography," Nevin M. Fenneman; "The Young Coasts of Annam and Northern Spain," W. M. Davis.

Journal of Geography, for March, *Broadway at 156th Street, New York City; $1.00 per year, 15 cents a copy:* "The Real France," Emmanuel de Martonne; "Relations Between Economic and General Geography," Wallace E. Whitehouse; "Utilizing Current News in Geography Teaching," O. D. Von Engeln.

Photo-Era, for March; *Boston, Mass.; $2.00 per year, 20 cents a copy:* "Race Between Camera and Amateur," Arthur Palme; "Winter-Photography in the City," Allen E. Churchill; "Stop!" Frederick C. Davis; "Photographing an Eclipse with Ordinary Apparatus," William

S. Davis; "Lantern-Notes," The Amateur Photographer; "By Other Lights" (Sixth of the "Professor Pyro" Talks), Michael Gross; "Photo-Era's War-Prints Competition," Wilfred A. French; "Practical and Humorous Experiences in Photography—Part II," A. H. Beardsley; "Stripping Negatives for Storage as Gelatine-Films," The British Journal.

Popular Astronomy, for April; *Northfield, Minn.; $3.50 per year:* "Meteorites and Meteors," William H. Pickering; "Night," Alice Berlingett; "The 72-Inch Reflecting Telescope of the Dominion Astrophysical Observatory, Victoria, B. C." (with Plates XII-XVI; "A Study of the Cycles of Encke's Comet," David A. Blencoe; "A Graphical Solution of the Astronomical Triangle," W. Carl Rufus; "Visual Estimates of the Brightness of Nova Aquilae, No. 3," Joel Stebbins; "A Suggestion as to Satellite Evolution," William H. Pickering.

Physical Review, for March; *Ithaca, New York; $6.00 per year, 60 cents a copy:* "The Structure of Radioactive Elements," Ingo W. D. Hackh; "On the Vibrations of Elastic Shells Partly Filled with Liquid," Sudhansukumar Banerji; "The Relation of Potential Distribution to Hysteresis Effect in the Wehnelt Tube," R. A. Porter; "Electric Discharge on the Surface of a Solid Electrolyte," Was. Sulejkin; "Magneto-striction with Special Reference to Pure Cobalt. Part I. The Wiedemann Effect," Howard A. Pidgeon; "On the Mechanical and Electrodynamical Properties of the Electron: Addendum," Megh Nad Saha.

WHAT ONE OF OUR BOYS DID FOR LIBERTY.

An Illinois boy, who has returned from the battlefield overseas covered with glory and with medals bestowed for bravery in the air, is now on a tour of the state of Illinois boosting the Victory Liberty Loan "finishing the job." He is Adjutant Glen Sitterly, of Spring Valley, Bureau county. This twenty-one year old lad, an "ace" of the air, with a long record of daring deeds and thrilling fights, is now an "ace" of the Liberty Loan.

Adjutant Sitterly went to France in April, 1917, with the Beloit College Ambulance Unit. Upon arriving in France, he transferred to the French Foreign Legion, and then on into the French aviation service as a member of the Lafayette squadron. He was discharged from the French Army February 23, 1919, and returned to America in March, having been in America just four weeks.

Adjutant Sitterly has been decorated four times for distinguished service in action. He was decorated with the French Medaille Militaire by General Gouraud, which is the highest honor conferred on a flyer by France. He also wears the croix de guerre with three palms, and the Lafayette ribbon, presented by the French minister of War to Americans in the French aviation. He is a member of the French Squadron 38 which Captain Madon commands, Captain Madon having brought down 79 official German planes. This squadron is the most famous squadron in the French aviation, having brought down 117 official German planes. For that it received three citations, which gave to it the fourragere of the croix de guerre.

Sitterly was brought down three different times by German planes following fights in which his plane or motor was so damaged that he was forced to land just within the French lines.

Adjutant Sitterly started work on the front in September, 1917, as pilot of a three-seated photographic plane which took pictures back of the German lines; also did protection work for day bombing and kept general watch and patrols on the lines during calm periods on the front. Later, as is the custom in French aviation when a pilot starts flying on a larger, slower machine and makes good, he was transferred to a small scout machine.

PROBLEM DEPARTMENT.

Conducted by J. O. Hassler,

Crane Technical High School and Junior College, Chicago.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and solve problems here proposed. Problems and solutions will be credited to their authors. Each solution, or proposed problem, sent to the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The Editor of the department desires to serve its readers by making it interesting and helpful to them. If you have any suggestion to make, mail it to him. Address all communications to J. O. Hassler, 2337 W. 108th Place, Chicago.

SOLUTION OF PROBLEMS.

574. *Proposed by N. P. Pandya.*

Construct a triangle ABC given the distances from A to the circumcentre, incentre and orthocentre.

Solution by A. MacLeod, Aberdeen, Scotland.

Let O, I, P, be the circumcentre, incentre, and orthocentre of $\triangle ABC$ and let radius of the circumcircle OK, bisect BC in M.

Then AP = 2OM, AIK is a straight line, and KC = KI.

Hence the following construction:

Draw a circle with centre O and radius OK equal to OA (given).

Take M in OK so that OM = ½AP (given) and draw chord BMC $\perp$ OK

Produce KC to D so that CD = AI (given), and with centre K, radius KD, cut the circle in A.

581. *Proposed by A. MacLeod, Aberdeen, Scotland.*

The six straight lines which trisect the angles of a triangle meet in three points which form the vertices of an equilateral triangle.

Solution by the Proposer.

Let the angle bisectors adjacent to AB, AC, BC meet in L, M, N. Produce BL, CM to meet at K.

N is the incentre of $\triangle KBC$.

$\therefore NL = NM$, provided $KL = KM$,

i. e., if $BK-BL = CK-CM$ or $CM-BL = CK-BK$.

Let R, R_1, R_2, R_3 be the circum-radii of $\triangle$s ABC, ABL, ACM, BCK and let $A = 3\alpha$, $B = 3\beta$, $C = 3\gamma$.

Then $2R_1 \sin(\alpha+\beta) = c = 2R\sin C$. $\therefore R_1 = (R\sin C)/[\sin(\alpha+\beta)]$

Similarly, $R_2 = (R\sin B)/[\sin(\alpha+\gamma)]$ and $R_3 = (R\sin A)/[\sin(\beta+2\gamma)]$.

$$CM-BL = 2R_2\sin\alpha - 2R_1\sin\alpha = 2R\sin\alpha\left[\frac{\sin B}{\sin(\alpha+\gamma)} - \frac{\sin C}{\sin(\alpha+\beta)}\right]$$

$$= 2R\sin\alpha\left[\frac{\sin 3(\alpha+\gamma)}{\sin(\alpha+\gamma)} - \frac{\sin 3(\alpha+\beta)}{\sin(\alpha+\beta)}\right]$$

$$= 8R\sin\alpha[\sin^2(\alpha+\beta) - \sin^2(\alpha+\gamma)], \text{ since } \sin 3\theta = 3\sin\theta - 4\sin^3\theta$$

$$= 8R\sin\alpha \cdot \sin(2\alpha+\beta+\gamma)\sin(\beta-\gamma), \text{ since } \sin(\theta+\varphi)\sin(\theta-\varphi) = \sin^2\theta - \sin^2\varphi$$

$$= 4R\sin(\beta-\gamma)[\cos(\alpha+\beta+\gamma) - \cos(3\alpha+\beta+\gamma)]$$

$$= 4R\sin(\beta-\gamma)[\tfrac{1}{2} + \cos(2\beta+2\gamma)] \text{ since } \alpha+\beta+\gamma = 60^\circ$$

$$= 2R\sin(\beta-\gamma)[3-4\sin^2(\beta+\gamma)]$$

$$= [2R\sin(\beta-\gamma)\sin 3(\beta+\gamma)]/[\sin(\beta+\gamma)]$$

$$= \frac{4R\sin A\sin(\beta-\gamma)\cos(\beta+\gamma)}{\sin 2(\beta+\gamma)} = \frac{2R\sin A}{\sin(2\beta+2\gamma)} \cdot (\sin 2\beta - \sin 2\gamma)$$

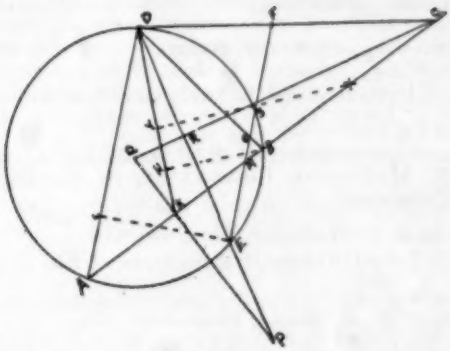
$= 2R_2(\sin 2\beta - \sin 2\gamma) = CK - BK.$

Hence KL = KM and NL = NM. Similarly LM = LN.

$\therefore \triangle LMN$ is equilateral.

589. *Proposed by N. P. Pandya, Amreli, Kathiawar, India.*

Given a chord AB of a circle, centre Q, produced to C and tangents CD, CE drawn. Let EF be drawn parallel to AD meeting AB in M, DB in O, the circle in S, and CD in F. Required—to find the position of C if F is the mid-point of CD.



Solution by A. MacLeod, Aberdeen, Scotland.

Analysis.

(1) Pencil D(AB, EC) is harmonic and EF || ray DA. $\therefore$ EO = OF.

(2) $\angle FMC = \angle DAB = \angle CDB$. $\therefore$ D, F, B, M are concyclic.

$\therefore OF \cdot OM = OB \cdot OD = OS \cdot OE$. $\therefore OM = OS$. $\therefore ES = MF = \frac{1}{2}AD$. Hence if $EL \perp AD$, $AL = AD/4$.

(3) Let the tangents at A and B meet in P.

The polar of P passes through C.

$\therefore$ the polar of C, viz., DE, passes through P.

The problem is now to draw a secant PED, such that if $EL \perp AD$, $AL = AD/4$.

(4) From similar triangles, $AE/AD = PA/PD = PB/PD = BE/BD$.

$\therefore AE \cdot BD = AD \cdot BE = \frac{1}{2}AB \cdot ED$ (*Ptolemy's Theorem*)

$\therefore$ if K be mid-point of AB, $AE/ED = BK/BD$, and $\angle AED = \angle KBD$

$\therefore$ triangles AEO, KBD are similar.

Hence if $BH \perp KD$, KH = KD/4.

Produce KB to X so that BX = BK and draw $XY \perp KD$.

Then Y is the mid-point of KD. $\therefore XK = XD$.

Construction.

Bisect AB at K. Produce AB to X so that BX = BK. With centre X, radius XK, cut the circle at D, and draw the tangent at D to meet AB at C.

Note: When AB is a diam. the problem may be solved by first finding the ratio AB : BC—a simple numerical ratio, 2 : 3.

The following solution reached the Editor too late for publication with the other solutions of the problem in the February issue.—*Editor.*

584. *Proposed by Norman Anning.*

AD, BE and CF are the medians of the triangle ABC. Show that $\cot \angle ADB + \cot \angle BEC + \cot \angle CFA = 0$.

Solution by N. P. Pandya, Amreli (Kathiawad), India.

Draw $AX \perp BC$. Then $\cot ADB = DX/AX = (BD - BX)/c\sin B = (2a \cdot BD - 2aBX)/2ac\sin B = (a^2 - 2ac\cos B)/4\triangle =$

$$[a^2 - (c^2 + a^2 - b^2)]/4\triangle = (b^2 - c^2)/4\triangle$$

$\therefore \Sigma \cot A = [\Sigma (b^2-c^2)]/4\triangle = 0.$

A similar solution was also received from NELSON L. RORAY.—*Editor.*

Algebra.

596. *Proposed by Walter R. Warne, Dickinson College, Carlisle, Pa.*

Solve, $x^4-2x^3+x = a.$

Solution by M. H. Pearson, Montgomery, Ala.

This may be written in the form

$(x^2-x)^2-(x^2-x) = a$

which may be solved as a quadratic, giving

$x^2-x = (1\pm\sqrt{1+4a})/2,$

which is also a quadratic that may be easily solved, giving

$x = (1\pm\sqrt{3\pm 2\sqrt{1+4a}})/2.$

Solutions were also received from J. S. BYERS, M. J. LEVENTHAL, R. M. MATHEWS, R. T. MCGREGOR, PHILOMATHE, A. MACLEOD, NELSON L. RORAY *and the* PROPOSER.

597. *Proposed by R. T. McGregor, Elk Grove, Cal.*

Show that $n^7-7n^5+14n^3-8n$ is a multiple of 840 if n is an integer greater than 2.

I. *Solution by P. P. B. Brooks, Thomasville, Ga.*

$840 = 7\times\underline{|5}.$

$$n^7-7n^5+14n^3-8n = (n^2-2)(n-2)(n-1)n(n+1)(n+2)$$
$$= (n^2-9+7)(n-2)(n-1)n(n+1)(n+2)$$
$$(n-3)(n-2)(n-1)n(n+1)(n+2)(n+3)+7(n-2)(n-1)n(n+1)(n+2).$$

Since the product of m consecutive numbers is divisible by $\underline{|m}$ the first member of the last expression is a multiple of $\underline{|7}$ and the second member is a multiple of $7\times\underline{|5}$. For $n = 1$ or 2 the expression becomes zero. Therefore for integral values of n greater than two the given function is an integral multiple of $7\times\underline{|5} = 840$.

II. *Solution by L. E. Lunn, Heron Lake, Minn.*

$n^7-7n^5+14n^3-8n = (n^7-n)-7(n^5-2n^3+n)$ by a simple re-grouping of the terms.

By the extension of Fermat's theorem the first parenthesis of the right hand member is divisible by 7 and consequently the entire right hand member is a multiple of seven.

Furthermore the given expression is factored as follows,

$$(n-2)(n-1)(n)(n+1)(n+2)(n^2-2)$$

where the first five factors are consecutive numbers. It follows then that the expression is a multiple of 5 or 120. Since we have shown above that the expression is a multiple of 7 and also of 120 it is a multiple of their product, viz., 840.

Solutions were also received from E. KESNER, M. J. LEVENTHAL, A. MACLEOD, R. M. MATHEWS, M. H. PEARSON, NELSON L. RORAY, PHILOMATHE, W. J. RISLEY, WALTER R. WARNE, *and the* PROPOSER.

Geometry.

598. *Proposed by the Editor.*

Describe a circle through two given points tangent to a given circle.

Solution by L. E. Lunn.

This is an old problem in this journal, the writer having proposed the equivalent under "Geometry" 403. Vol. XIV. Solutions were published at that time by E. L. Brown, L. E. A. Ling, and A. E. Jeffery.

The traditional solution is the tangent and secant method which was

among the published solutions at that time, it is also given in full in Stone-Millis Plane geometry, original edition, page 189.

Query. Is there an impossible case as stated by Mr. Jeffery in his solution? Is there a case when but one construction is possible?

I. *The traditional solution. Stated by Nelson L. Roray.*

Let A and B be the given points. Construct any circle passing through A and B cutting the given circle at C and D. AB and CD intersect at P. The tangents from P to the given circle determine the required points of tangency. There are two solutions. The proof is easy and the rest of the construction evident.

Angus MacLeod, Aberdeen, Scotland, appends to a similar statement the remark that this construction fails if AB is parallel to CD, in which case the perpendicular from the center of the given circle to AB is perpendicular to CD and bisects AB and CD. The intersections of this perpendicular with the given circle will determine the points of tangency.—*Editor.*

Similar solutions were received from R. M. MATHEWS, C. N. MILLS, *and* PHILOMATHE.

Two New Solutions.

II. *Solution by Philomathe (A. Pelletier) Montreal, Canada.*

Given points A and B and circle O. Draw tangent AT to circle, and take C on AB such that $AB \cdot AC = AT^2$. From C draw tangents CD, CE to circle. From A draw $\perp$'s AO′ and AO″ to CD and CE. At the mid-point of AB erect a $\perp$ to AB, intersecting AO′ and AO″ at O′ and O″, the centers of the required circles.

To prove it take A as the origin and AT^2, as the power of inversion. Then, it is evident, by the theory of inversion, that circles O′ and O″, corresponding to tangents CD and CE, are also tangents to circle O.

Solution by C. N. Mills, State College, Brookings, S. Dakota.

Let A and B be the given points, and O the center of the given circle. Join the given points by straight line, AB. Through either point A or B, say B, draw a line through O, and letter the points where the line cuts the circumference, M and N. Make BE a fourth proportional to BA, BN, and BM. From E draw tangents EH and EK. From B draw BR and BS through the points of tangency just found, H and K. Note the intersections R and S of the lines with the given circle. Through the three points A, B, and R, or A, B and S draw a circle; either of these circles will satisfy the required condition.

The Editor suggests as a problem the proof of the above.

Solutions were also received from A. H. GRETSCH, M. H. PEARSONS, *and* W. R. WARNE.

599. *Proposed by Walter R. Warne.*

If A, B, C, D be any four points on a circle and O any fifth point taken arbitrarily, and if we denote by BCD the area of the triangle BCD, etc., then

$$OA^2 \cdot BCD + OC^2 \cdot ABD = OB^2 \cdot ACD + OD^2 \cdot ABC.$$

Solution by A. MacLeod.

A, B, C, D are four points on a circle and O is a fifth arbitrary point. To prove:

$OA^2 \cdot \triangle BCD + OC^2 \cdot \triangle ABD = OB^2 \cdot \triangle ACD + OD^2 \cdot \triangle ABC.$

Proof:

Let AC and BD intersect in P.

$\triangle BCD / \triangle ABD = PC/AP \quad \therefore BCD/ABCD = PC/AC$ and $ABD/ABCD = AP/AC$.

Also in $\triangle OAC$, $PC \cdot OA^2 + AP \cdot OC^2 = AC(AP \cdot PC + OP^2)$ (Lemma) now

$(OA^2 \cdot BCD + OC^2 \cdot ABD)/ABCD = OA^2 \cdot PC/AC + OC^2 \cdot AP/AC$
$= AP \cdot PC + OP^2$

Similarly $OB^2 \cdot ACD + OD^2 \cdot ABC = ABCD(BP \cdot PD + OP^2)$

Hence the proposition is proved since $AP \cdot PC = BP \cdot PD$.

[Proof of Lemma: Draw $OM \perp AC$.

$OA^2 = AP^2 + OP^2 + 2AP \cdot PM.$ (1)

$OC^2 = PC^2 + OP^2 - 2PC \cdot PM.$ (2)

Multiply (1) by PC and (2) by AP and add.]

A similar solution was received from PHILOMATHE *and two solutions by means of analytic geometry from the* PROPOSER.

600. *Proposed by Walter R. Warne.*

Eliminate θ from the equations,

$x = a(\sin 3\theta - \sin\theta)$ (1)

$y = a(\cos\theta - \cos 3\theta)$. (2)

I. *Solution by R. M. Mathews, Central High School, Duluth, Minn., and, with slight variations, by Nelson L. Roray and Philomathe.*

Standard formulas give the reductions,

$x = 2a\cos 2\theta \sin\theta \qquad y = 2a\sin 2\theta \sin\theta$ (3)

$\therefore x^2 + y^2 = 4a^2\sin^2\theta$ (4)

But $y = 4a\sin^2\theta\cos\theta$ [From (3)]

$\therefore ay/(x^2+y^2) = \cos\theta$ (5)

(4) and (5) then give

$(x^2+y^2)^3 - 4a^2(x^2+y^2)^2 + 4a^4y^2 = 0.$

II. *Solution by Murray J. Leventhal, Stuyvesant H. S., N. Y. C.*

Dividing (2) by (1), $y/x = \tan 2\theta \qquad \therefore \sin 2\theta = y/(\sqrt{x^2+y^2})$ and $\cos 2\theta = x/(\sqrt{x^2+y^2})$. Adding (1) and (2), we have, $x + y = 2a\sin\theta(\sin 2\theta + \cos 2\theta)$. Substituting for $\sin 2\theta$, $\cos 2\theta$, and $\sin\theta$, the last derived from the value of $\cos 2\theta$, we obtain, after simplifying

$(x^2+y^2)^{\frac{1}{2}}(x^2+y^2-2a^2) + 2a^2x = 0.$

III. *Solution by A. MacLeod.*

$x = 2a\sin\theta\cos 2\theta$

$y = 2a\sin\theta\sin 2\theta$

$\therefore x^2 + y^2 = 4a^2\sin^2\theta.$

$\therefore 2a^2 - x^2 - y^2 = 2a^2(1 - 2\sin^2\theta) = 2a^2\cos 2\theta$

$\therefore (x^2+y^2)(2a^2 - x^2 - y^2)^2 = (4a^2\sin\theta\cos 2\theta)^2 = (2a^2x)^2 = 4a^4x^2$

Another form of the eliminant is $(x^2+y^2)^2(4a^2 - x^2 - y^2) = 4a^4y^2$.

The following solution is one of six different solutions of this problem from Professor Cobb, the Mathematics Editor.

$x = a(\sin 3\theta - \sin\theta)$ (1)

$y = a(\cos\theta - \cos 3\theta)$ (2)

$xy = a^2[(\sin 3\theta\cos\theta + \cos 3\theta\sin\theta) - (\sin\theta\cos\theta + \sin 3\theta\cos 3\theta)]$

$= a^2(\sin 4\theta - \tfrac{1}{2}\sin 2\theta - \tfrac{1}{2}\sin 6\theta)$

$= a^2[\sin 4\theta - \tfrac{1}{2}(\sin 6\theta + \sin 2\theta)]$

$= a^2(\sin 4\theta - \sin 4\theta\cos 2\theta)$

$= a^2\sin 4\theta(1 - \cos 2\theta)$

$xy = 2a^2\sin 2\theta\cos 2\theta(1 - \cos 2\theta)$ (3)

$\sin 2\theta = y/(\sqrt{x^2+y^2}),\ \cos 2\theta = x/(\sqrt{x^2+y^2})$ [From II]

Substitute in (3) and simplify,

$2a^2x\sqrt{x^2+y^2}(2a^2 - x^2 - y^2) = 0.$

There were three incorrect solutions to this problem.

Late Solutions.

Angus MacLeod, 591, 592, 593, 594, 595.
H. A. Simmons, 591, 592, 593.
R. M. Mathews, 595.
S. H. Parsons, 591.

N. P. Pandya, 576, 582 (By intersection of ellipse with circle), 583, 585.

Problems for Solution.

611. *Proposed by A. MacLeod, Aberdeen, Scotland.*

Solve $2b(\sqrt{x+a}-b)+2c(\sqrt{x-a}+c) = a.$

612. *Proposed by R. T. McGregor, Elk Grove, Cal.*

Find four mixed numbers in arithmetical progression whose common difference is two and the sum of whose squares is a square.

613. *Proposed by N. P. Pandya, Amreli (Kathiawad) India.*

Describe a circle to touch two given circles and a given straight line.

[Sequel to 598 and 603 and 608. Problem of Appollonius next month. —*Editor.*]

614. *Proposed by Daniel Kreth, Wellman, Iowa.*

Having given the base, the line bisecting the vertical angle, and the diameter of the circumscribing circle, to construct the triangle and determine its sides.

615. *Proposed by Walter R. Warne, Carlisle, Pa.*

Eliminate θ and φ from

$$c\sin\theta = a\sin(\theta+\varphi), \quad (1)$$

$$a\sin\varphi = b\sin\theta, \quad (2)$$

$$\cos\theta-\cos\varphi = 2m. \quad (3)$$

Correction.

Problems 603 and 608 were stated alike by mistake. Substitute for 603 the following:

603b. *Selected.*

Construct a circle passing through a given point, tangent to a given line and a given circle.

UNITED STATES NAVY OFFERS WONDERFUL OPPORTUNITIES TO YOUNG MEN SEVENTEEN TO THIRTY-FIVE —ENLISTMENTS OPEN.

The U. S. Navy is open for voluntary enlistments and is offering many wonderful opportunities to young men between the ages of seventeen and thirty-five who enter the service at this time. At the present time, men are particularly desired in the following branches: Machinists, Apprentices, Hospital Apprentices, Firemen, and Electricians.

An opportunity to attend the Navy Machinist School and receive a valuable education in machine work is offered young men between the ages of eighteen and thirty-five. Men eligible for this branch must have had a small amount of machine shop experience.

Young men eighteen to twenty-five years of age and who have a fair education may enlist in the Hospital Corps and receive a training of high degree, in the following subjects: Anatomy, First-Aid, Emergency-Surgery, Pharmacy, Chemistry, etc. Those who show ability may avail themselves of courses in Elementary Bacteriology, laboratory examinations, tests, X-ray, etc.

Men eighteen to thirty-five years of age and who have had some fireroom experience and who are especially desirable may enlist as firemen.

Young men seventeen years of age may enlist as Apprentice Seamen with the consent of their parents or guardians.

The U. S. Navy Recruiting Station, Transportation Bldg., Chicago, Ill., has complete information and literature covering all branches of the service that are now open for enlistment, and inquiries addressed to that station will receive prompt attention.

SCIENCE QUESTIONS.

Conducted by Franklin T. Jones.

The Warner & Swasey Company, Cleveland, Ohio.

Readers are invited to propose questions for solution—scientific or pedagogical—and to answer questions proposed by others or by themselves. Kindly address all communications to Franklin T. Jones, 10109 Wilbur Ave., S. E., Cleveland, Ohio.

Please send examination papers on any subject or from any source to the Editor of this department. *School examinations of all sorts are wanted. If you have run across anything queer, be sure to send it in.*

QUESTIONS AND PROBLEMS FOR SOLUTION.

322. A *practical* question *seriously* considered.

The optics in certain gun sights showed a bloom when inspected. The hypothesis was, that the "acid from the workmen's breath" produced this bloom by acting on the glass. It was also stated that the bloom was worse when the workmen's breath "smelled of onions."

[The above is quoted in all seriousness. It was abstracted from the letter of a Government inspector.]

Can anyone offer an explanation—scientific or otherwise?

323. *Proposed by J. C. Packard, Brookline, Mass.*

What is the horse power required to drive an automobile weighing 2,000 lbs. up an 8% grade at the rate of 30 miles per hour?

CONTRIBUTION.

The following list of review questions was contributed by P. M. Dysart, *Schenley High School, Pittsburgh, Pa. What have you that would be similarly useful? Send it in.*

324.

LIGHT.

1. *a.* Table of the cases of mirrors in which the image is smaller than the object.

b. Table of cases of lenses in which the image is larger than the object.

2. *a.* (1) Location of an object with reference to a concave mirror in order that the image may be larger and erect?

(2) With reference to a convex lens in order that the image may be at the principal focus?

(3) With reference to a concave lens in order that the image may be smaller and real?

(4) Labeled sketch showing the action of an automobile headlight.

b. An object 4 cm. high is 4 cm. distant from a concave mirror whose radius of curvature is 16 cm. Find by construction the location and height of the image. Check by calculation.

3. *a.* An object 4 cm. high is 7 cm. distant from the optical center of a convex lens whose focal length is 3.5 cm. Find by construction the location and height of the image. Check by calculation.

b. An object 4 cm. high is 7 cm. distant from the optical center of a concave lens whose principal focus is 3.5 cm. distant from its optical center. Find by construction the location and height of the image. Check by calculation.

4. *a.* What must be the focal length of a telescope objective in order that it may form an image of the moon, 1 foot in diameter?

b. (1) Labeled sketch of a compound microscope.

(2) Calculate the magnifying power of the microscope. The focal length of the objective is 1/6 inch, of the eyepiece, 1/2 inch.

5. *a.* (1) Sketch showing the effect of an air-water surface upon Y light, angle of incidence in air being 50 degrees. Give the value of each of the angles.

(2) Same for a diamond-air surface, angle of incidence in diamond being 25 degrees. The index of refraction of diamond is 2.5.

b. Labeled sketch of apparatus used to project the spectrum of light that had passed through a substance having the property of selective absorption.

6. *a.* (1) Sensation produced by a mixture of black, V, and G sensations?

(2) Of black, V, G, and R sensations? (3) Of black, weak G, and strong Red sensations? (4) Color sensation produced by the light reflected from copper when illuminated by pure V light? By pure G light? By W light?

b. (1) Color triangle for pigments. (2) Result of mixing Y, B, and W pigments? The pigments have the character of selective absorption required by the theory of the triangle. (3) Of mixing V, G, and Blk?

7. *a.* Solution A absorbs Blue. Sol. B transmits V, Y_2, R_2. Sol. C transmits V, Y_1, R. Color sensation produced by light transmitted by a mixture of A, B, and C?

b. (1) Color sensation produced by light transmitted by A?

(2) By B? (3) By C?

8. *a.* Fully labeled sketch showing method of producing Röntgen rays and of making their presence known.

b. Sketch of the Röntgen-ray shadow upon a Ba Pt $(CN)_4$ screen of the hand with a gold ring on a finger.

9. *a.* (1) What is the radiant efficiency of a gas or vapor whose complete spectrum consists of a bright line whose wave length is .55 micron?

(2) 1 Watt of electrical power would cause such a gas or vapor to produce how many lumens?

(3) 1 Watt of electrical power causes a vacuum tungsten lamp to produce how many lumens?

b. What is the intensity of illumination 10 feet distant from a source of light of 80 m. s. cp., which sends out light equally in all directions?

10. *a.* (1) Explain the effect of a soap-bubble film .3 micron thick upon V light. (2) Upon Y light. (3) Of a film .0001 micron thick upon W light.

b. (1) Show by a sketch what is meant by chromatic aberration of a lens. (2) By distortion produced by a lens. (3) Show by a sketch how distortion can be prevented.

SOLUTIONS AND ANSWERS.

303. *From a Sheffield Scientific School, Semi-annual Examination.*

Find the magnetic intensity on the prolongation of the axis of a bar magnet 30 cm. from one of the poles, the strength of each pole being 1200 units and the distance between the two poles being 20 cm.

Solution by G. H. P. Gannon, The Warner and Swasey Apprentice School, Cleveland, Ohio.

Let m = strength of poles.

Let r = distance of point (P) from center of magnet.

Let l = distance of either pole from center of magnet.

Coulombs law, $F = mm'/r^2$.

(1) The force on a unit north pole placed at P, due to the north pole would be,

$$m/(r-l)^2$$

(2) The force on a unit south pole placed at P, due to the south pole would be,

$$m/(r+l)^2$$

Therefore the resultant force at P is

$$F = m/(r-l)^2 - m/(r+l)^2$$
$$= 4rlm/(r^4-2r^2l^2+l^4)$$
$$= (4\times40\times10\times1200)/(400^4-2\times40^2\times10^2+10^4) = .000075 \text{ dynes.}$$

304. *From the same source.*

What is the maximum E. M. F. in such a coil of 50 turns having a diameter of 40 cm. when this rotates 1200 times per minute about an axis perpendicular to a field of 300 units?

Solution by G. H. P. Gannon.

B = density in lines per sq. cm. = 300.

l = length of conductor = 20π = 62.8 cm. ($nl = 50\times62.8$).

V = velocity of conductor in cm. per sec. = $40 \times \pi \times 1200/60$ = 2512 cm. per sec.

E. M. F. = $B(nl)V$
= $300 \times 50 \times 62.8 \times 2512$
= 2,366,295,000 in C. G. S. units
= 23.66295 volts.

314. Are teachers and pupils satisfied with the questions asked on college entrance examinations in physics, especially Board examinations?

Here is your chance to offer suggestions.

"Is there anything to be said about the comprehensive physics, or chemistry, papers of the College Entrance Board? In the absence of any criticisms or suggestions from teachers in active service, the Board will be justified in considering that the papers are satisfactory. Speak up, gentlemen. [Signed] John C. Packard, Brookline, Mass., member of Committee on Revision."

In answer to the above, propose questions, or a series of questions, such as the Board **ought** to use.

Editor's Note: No answers received. We silently O. K. the College Board examinations. The editor, being one of those not "in active service," may still be privileged to "take a shot" at the Board exams.

315. *Proposed by James C. McClymont, Chester, Pa.*

How much power is developed by a man who weighs 160 pounds, walking on a level cement pavement for a distance of 300 feet, in 30 seconds?

Solution by an anonymous contributor.

Power = ($w \times$space)/time
= $(160 \times 300)/30$ = 1600 ft. lbs.
H. Power = 1600/550 = 32/11 = 2.9+.

ELECTRICAL SALES FOR 1918.

It becomes apparent that sales of electrical equipment billed in 1918 are not much greater, if greater at all, than those billed during the record year of 1917. In fact, in not a few instances it will be found that gross sales for 1918 are below those for 1917.

If the above is true, then the sales of electrical goods billed in 1918 will probably be found to run around $750,000,000.

A good many reasons can be found for sales not running higher. First, there was not the quantity of new factory space in 1918 that there was for 1917 production. Second, there was less commercial and more government purchasing. Third, the shortage of raw materials and labor reduced production in many lines. Fourth, conservation measures required curtailment in the output of a number of electrical products. Fifth, the signing of the armistice early in November caused a very large reduction in output. Sixth, government prices on raw materials brought lower average prices on certain lines, particularly wire, which has the largest output in dollars and cents of all electrical manufactures.

At the close of 1917 the unfilled orders on hand were very large. Some of these orders have not yet been filled. Unfilled orders now on hand are probably much smaller than they were a year ago. The close of the war brought many cancellations. All government contracts, however, were not canceled. The big government contract for outpost wire, for instance, still remains in the process of fulfillment.

When the new year opens the electrical manufacturing industry will find itself in a better condition to attract business than it has been in for the past two years. Once more it will be able to give service to buyers.— *Electrical World.*

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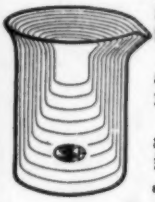

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BOOKS RECEIVED.

The Living Cycads, by Charles J. Chamberlain, University of Chicago. Pages xiv+172, 14x19 cm. Cloth, 1919. $1.50. University of Chicago Press.

Education Survey of Elyria, Ohio. Made under the Direction of the U. S. Commissioner of Education. 300 pages, 14.5x23 cm. Paper, 1918. 30 cents. Government Printing Office, Washington.

Introductory Mathematical Analysis, by W. Paul Webber, University of Pittsburgh, and Louis C. Plant, Michigan Agricultural College. Pages xiii+304, 14x21 cm. Cloth, 1919. John Wiley and Sons, New York City.

The Arthrostraca of Connecticut, by B. W. Kunkel, Lafayette College, 261 pages, 14.5x23 cm. Paper, 1918. 80 cents. State Geological Survey, Hartford.

The Training of the Teachers of Mathematics, by Raymond C. Archibald, Brown University, with the Cooperation of D. E. Smith, W. F. Osgood, and J. W. A. Young. 289 pages, 14.5x23 cm. Paper, 1918. 30 cents. Government Printing Office, Washington.

Junior High School Mathematics, by E. H. Taylor and Fiske Allen, State Normal School, Charleston, Ill. Pages ix+210, 12.5x18.5 cm. Cloth, 1919. Henry Holt and Company, New York City.

The German School as a War Nursery, from the French Pédagogie de Guerre Allemande, by V. H. Friedel, Paris. Translated by Major Selwyn G. Simpson. 270 pages, 12.5x18 cm. Cloth, 1918. $1.30. The Macmillan Company, New York City.

The Elements of Astronomy, by Charles A. Young, late of Princeton University. Pages x+508, 13x19 cm. Cloth, $2.00. Ginn and Company, Boston, Mass.

American Agricultural Colleges, by Chester D. Jarvis, Specialist in Education, Bureau of Education. 125 pages, 15x23 cm. Paper, 1918. 15 cents. Government Printing Office, Washington.

ALTITUDES OF PLACES IN ILLINOIS.

The exact altitudes of more than 1,500 places in Illinois, as determined by the United States Geological Survey, Department of the Interior, are given in the Survey's Bulletin, 672, "Results of Spirit Leveling in Illinois, 1914 to 1917, inclusive," which gives also many less exact elevations of well-known places. The work was done in cooperation with the State Geological Survey of Illinois, an equal allotment of funds having been made by each organization. The highest point in the State thus far determined is Charles Mound, in Jo Daviess County, which is 1,241 feet above mean sea level.

The topographic maps published by the Survey show the elevations of points within the areas mapped to the nearest foot, whereas the bulletins on spirit leveling show elevations to thousandths of a foot.

BOOK REVIEWS.

Farm Science, A Foundation Textbook on Agriculture, by W. J. Spillman, U. S. Department of Agriculture. Pages vii+344. 14x19 cm. Cloth. 1918. $1.28. World Book Co., Yonkers, New York.

The function of this splendid book is fundamentally to explain to the boy, whether he be a farm boy or working boy's reserve boy, the many facts about farming. The simple processes of farm life and industry are splendidly described.

The author does not go into the theory of soil production or soil analysis. He treats of concrete facts about which the boy is likely to center his thoughts. The book can be used in many schools as a laboratory manual, and it may be used in any high school in any part of the country, it is so universal. No attempt is made to teach the boy those things which the boy on the farm will learn by experience. There are 174 half tones scattered throughout the text, all showing wise selection.

The mechanical part of the book is well done. It is divided into four main parts, namely, the soil, the plant, the animal, and the farm.

It is well written, makes interesting reading, and will hold the attention of any boy who is a lover of nature, the country, and the farm.

There are nine two-column pages of splendid index. The book deserves a wide circulation. C. H. S.

A Chemistry Library for Secondary Schools. A report of a Committee Appointed by the New England Association of Chemistry Teachers. Paper. 16 pages. S. Walter Hoyt, Secretary, Mechanic Arts High School, Boston, Mass.

This is without question the best list of books in chemistry for secondary school teachers ever published. A committee of three, consisting of William Segerblom, chairman, Charles H. Stone, and H. Milton Thayer, spent many weeks of careful thought, study and investigation, reading and reporting on each and every one of the texts that are published in the report. Every book named therein is worth while. There are over one hundred and forty books listed, and they were selected from nearly twice that number examined.

The publishers of the texts as well as the number of pages, the year of publication, and the price, are printed.

The pamphlet is divided into divisions treating of books on general chemistry, including organic, inorganic, and physical chemistry, books on industrial chemistry, household chemistry, analytic chemistry, photographic chemistry, textile chemistry, electro chemistry, metallurgy, explosives, radio-activity, history and biographic tables of physical

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and chemical constants, and miscellaneous. Also a selected twenty-five dollar, as well as a fifty dollar, list is given.

Every chemistry teacher should possess a copy of this report. C. H. S.

Modern Americans, by Chester Sanford and Grace A. Owen, Illinois State Normal University, Normal, Illinois. 208 pages. 1918. Cloth. Laurel Book Co., Chicago.

A splendid little book containing the epitome of what twenty-four modern Americans have accomplished. Each one of these twenty-four has been a national character, and will be recognized by almost every high school boy. The book tells about "real folks." There may be some disagreement among readers with reference to the choice of the characters used, yet no one can say that these names have not made their mark in the world. The book is one that English teachers of the first year high school at least, should use in their classes. C. H. S.

Modern Arithmetic, by Bruce M. Watson, formerly Superintendent of Schools, Spokane, Wash., and Clarence E. White, Principal of Franklin School, Syracuse, N. Y. Primary, pages viii+252. Intermediate, pages x+254. For Upper Grades, pages ix+302. 13x19 cm. 1918. D. C. Heath & Co., New York.

In the preparation of this series the authors were guided by the following considerations: Thoroughness in the fundamentals, choice of applications, simplification of processes, problems from real life, continuity of plan and recognition of differences in ability of children. The books show that these principles have been carefully followed out, and they offer an excellent course in Arithmetic. Pupils are encouraged to secure data and make up problems. Large size type, many diagrams and pictures, tabular arrangement of data and definitions and rules printed in a manner to make them stand out distinctly, make the work of teacher and pupils easier. H. E. C.

Solid Geometry, by C. I. Palmer, Associate Professor of Mathematics, Armour Institute of Technology and D. P. Taylor. Edited by Geo. W. Myers, Professor of the Teaching of Mathematics, School of Education, The University of Chicago. Pages vi+178. 12x18 cm. 1918. Scott, Foresman & Co., Chicago.

A book of convenient size, well spaced and with well arranged pages, abundance of practical applications, sufficient abstract exercises, more important theorems in heavy type, applications of arithmetic, and algebra to geometry, some proofs of theorems left to students, suggestions for making models, figures that enable the student to see three dimensions in a flat picture, omission of unnecessary theorems, are some of the things that will make a teacher want to use this book.

The prolonged study of the aims and methods of teaching mathematics and years of successful work in the class room by the persons responsible for this book are a warrant that it will meet the needs of teachers and pupils. H. E. C.

Elementary Mathematical Analysis, Second Edition, Revised and Entirely Reset, by Charles S. Slichter, Sc.D., Professor of Applied Mathematics, University of Wisconsin. Pages xi+497. 13x19 cm. Price $2.50. 1918. McGraw-Hill Book Co., Inc., New York.

The most important topics of college algebra, trigonometry, and analytic geometry are included in this book. Simplification of the material has been the main purpose in making the revision. Considerable material has been omitted and many worked exercises have been added. While the fundamental truths of elementary analysis are presented and discussed in a way to afford the student a proper understanding of theory, the main emphasis seems to be placed on doing things, as it ought.

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New Books for Field Work in Biology.

Fresh-Water Biology, by Henry B. Ward, University of Illinois, and George C. Whipple, Harvard University. Pages ix+1111, 1,547 illustrations. Cloth. John Wiley and Sons, New York City.

A Field and Laboratory Guide in Biological Nature Study, by Elliot R. Downing, University of Chicago. 120 pages, 15.5x22 cm. Loose leaf. Paper, 1918. $1.00. University of Chicago Press.

Animal Communities in Temperate America as Illustrated in the Chicago Area, by Victor E. Shelford, University of Illinois. Pages xiii+362, 9 diagrams, 306 figures, 2 maps, 17x27 cm. Cloth. The Geographic Society of Chicago.

Life in Inland Waters, by James G. Needam and J. L. Lloyd, Cornell University. 438 pages, 244 illustrations, 15x23 cm. Cloth, 1916. Comstock Publishing Co., Ithaca, New York.

Biology teachers in secondary schools have had to labor under discouraging difficulties in carrying on field work with their classes and even for improving their own fund of knowledge of animals and plants in their habitats. Books on the higher vertebrates and the flowering plants and ferns have been accessible and have of recent date been very good, but information for field study and classification of the lower forms of plant and animal life, especially those forms living in the water, have existed chiefly in monographs and other publications which were practically inaccessible to high-school teachers.

Within the last two or three years several very helpful books along these lines have been published. The older ones have already been reviewed in this magazine as they appeared from the press, but during the past year two more books have come off the press, one of which is of such importance and represents such a colossal undertaking that it has been thought best to give the book more than the ordinary notice.

Fresh Water Biology. Twenty-seven people collaborated in the preparation of this book, each a specialist in some field of biological work. Each of the collaborators has prepared a chapter on a single group with which he is most familiar by years of study. The same general plan of work is used in the preparation of all the chapters except a few chapters of a general character. The first three chapters, including the "Introduction," by the senior editor, "The Conditions of Existence," by Victor Shelford, and "Methods of Collecting and Photographing," by Jacob Reighard, form an introduction to the studies of specific groups of animals and plants that follow. They are exceedingly valuable chapters, giving as they do a conception of the meaning of life in fresh waters and its limitations. The third chapter with its detailed suggestions of methods and descriptions of apparatus will be especially valuable.

The remaining chapters take up specific divisions of animal and plant life. "Each chapter is devoted to a single group of organisms and opens with a general account of the occurrence and history of the group." The "general account" of the group includes a discussion of biological factors of interest in the particular group, and wherever needed there are special suggestions and directions for collecting. The key that follows may be carried to species but usually to genera, depending upon the size of the group. The keys are profusely illustrated, usually with drawings specially made for this work by the authors. At the close of the chapter there is a list of important references for further study of the group.

Standard Books for High Schools

THE HAWKES-LUBY-TOUTON ALGEBRAS

First Course in Algebra (Revised)	$1.08
Second Course in Algebra (Revised)	1.00
Complete School Algebra	1.40

THE WENTWORTH-SMITH GEOMETRIES

Plane Geometry	$ .92
Solid Geometry	.88
Plane and Solid Geometry	1.40
Millikan and Gale's First Course in Physics (Revised)	1.40

THE McPHERSON AND HENDERSON CHEMISTRIES

Elementary Study of Chemistry (Second Rev. Ed.)	$1.60
First Course in Chemistry	1.40
Caldwell and Eikenberry's Elements of General Science (Revised)	1.28

THE BERGEN AND CALDWELL BOTANIES

Introduction to Botany	$1.36
With Key and Flora	1.64
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Waters's Essentials of Agriculture	1.40
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"School Science and Mathematics" bears the same relation to progressive Science and Mathematics Teaching as does the "Iron Age" to the Hardware business. No up-to-date Hardware merchant does without his trade Journal. Every Science and Mathematics teacher should be a subscriber to the professional trade Journal, "School Science and Mathematics."

Some chapters have presented opportunities for treatment of much broader interest than that of the group under discussion. Such are the chapters on Rotifera by Jennings and on Copepoda by Marsh. The former gives an admirable discussion of life processes and the latter of general distribution as illustrated by this group. Eigenmann discusses the aquatic vertebrates in a purely biological way, "since a systematic outline would require an entire book for its presentations." For the same reason the chapter on bacteria by Jordan is a general discussion of this group. The chapter on the "Larger Aquatic Vegetation," by Pond takes up the chemico-physical aspects of these plants and is a very valuable chapter.

Perhaps enough has been said to show that here is a mine of wealth for the biology teacher in the high schools. His danger of becoming content with a narrow outline is very great, more especially since the daily tasks occupy so much of his energy and time. Books of this sort stimulate and broaden the vision of the teacher. But their value in another way is even greater. The collecting instinct in young people is strong and is a potent means for stimulating interest. Studies of birds have been valuable on this account and have been very successful because there were means for identifying the birds when discovered. Now that we have keys for the aquatic life as well as for the larger land organisms, the teacher may approach field studies in these groups with more confidence. The small brook or pond offers many opportunities for surveys and studies of fascinating interest. Moreover these water animals may be studied in their reactions to environment much more readily than the larger land animals.

The preparation of such a book as this is largely a work of love and sacrifice; the reward is solely the hope of rendering some service to fellow students. The pecuniary rewards of such work are nil, more often considerable money must be advanced to finance the undertaking. We can only thank the editor-authors and their collaborators and buy a book. Every biology teacher should have one—for his own good and for the sake of his pupils, who profit much when given real glimpses of what is going on all about us.

Field and Laboratory Guide in Biological Nature Study. There is much danger of dissipation of energy with planless field trips. Any "field trip" or "field study" may have value—is bound to be "interesting," but gets nowhere if made without definite plans. Many teachers have had no college training in field study work and must formulate their own plans and make even their first acquaintance with life in the open when they begin their biology teaching—or do no field work. To many teachers, therefore, Dr. Downing's book will be a boon much needed. It gives specific suggestions and directions for field work. While it makes no attempt to be exhaustive there is enough for the beginning. It is the outcome of his own experience, therefore confined to topics that yield the highest returns.

Here is a list of the topics covered by the book: Some Common Insects, Autumn Weeds, Animals of Pond and Stream, Seeds and Seedlings, and The Garden. This is the list of the experienced teacher and if well carried out will give wonderful results in interest and vision of life around us. There are three keys, to autumn weeds, to trees, and to birds, all of the Chicago area, but, of course, of general application, with slight modifications, to other areas. There is much data as to methods given throughout the book, the outcome of years of work, which, brought together as it is under one cover, is invaluable to the inexperienced teacher. It takes many years and much labor to acquire the wide field

The Essentials of Modern Chemistry

By CHARLES E. DULL, South Side High School, Newark, N.J.

458 pp. 12mo. $1.40.

This book is not an industrial chemistry, although it presents numerous applications of chemistry to industry.

It is not a chemistry of everyday life, although it shows the importance of chemistry in daily life.

It is a clear, concise treatment of the science of chemistry, adapted to high school conditions. It does, however, show the great importance of chemistry in industry in such a manner as to make the subject interesting and to set up a motive for its study.

A critic of the manuscript thus summed up its good features:

"The author has used good judgment in the selection of topics for presentation, the sequence is orderly, the style interesting, and the summaries and questions at the ends of the chapters are excellent.

"The points of special merit are: First, that the author has been usually successful in showing the applications of chemistry to the most varied activities of everyday life, and, second, he has succeeded in developing a set of questions on the text that are not only helpful but interesting."

The Laboratory Study of Chemistry

By HERBERT R. SMITH and HARRY R. MESS of the Chicago High Schools

296 pp. Square 8vo. $1.20.

This manual makes a textbook an indifferent factor in a class and will save both teacher and students a great deal of time and useless labor. The student is enabled to do the work intelligently, that is, with a purpose clearly in mind; and then with the guidance of the manual he reviews the experiment in order to verify his results. Many students will learn early to take care of themselves except for occasional suggestions or guidance by the instructor, while the instructor's time is freed to give attention to those students who need it most.

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of knowledge that is needed for successful field work with high school classes, not that the knowledge needed is profound, but that it must be so wide and intimate. Dr. Downing has done a real service to the cause of nature study in publishing his notes.

Animal Communities in Temperate America. Dr. Shelford's book supplements "Fresh Water Biology," by using the point of view of ecology instead of the group. The animals to be found living together in one community are the unit of study.

Life in Inland Waters. This is a textbook of aquatic life. It studies life by the group method rather than the community, but does not by any means lose sight of the ecological and biological factors.

The four books we have brought together in this paper are a wonderful addition to the equipment of the biology teacher. We are sure that they will greatly stimulate the right kind of teaching in the high schools. Their influence must react upon the teacher himself who needs to be reaching out and broadening his vision as well as acquiring more exact knowledge of animals and plants. Biology needs more people who are students—we need not say research workers—just plain students working out some problem. These four books can open up a world of problems to the student looking for them. W. W.

The Elements of Animal Biology, by S. J. Holmes, University of California. Pages x+402. 14x20 cm. Cloth, 1918. $1.35 net. P. Blakiston's Son & Company, Philadelphia, Pa.

The book consists of three parts: I. The Animal Kingdom; II. The Elements of Physiology; III. General Features and Adaptations. The first two parts are in the usual style, but the third part shows originality in the presentation of some important topics. These are the perpetuation of life, the evolution of life, divergence and adaptation, and heredity and human improvement.

We must confess that from the standpoint of the teacher in the high school there seems to be no reason for adding this book to our list of science texts written by college men. Teachers of science in high schools are endeavoring to make the subject mean more to the student by using the problems met with in every-day life as a basis for the work. In the biological subjects this is particularly true and teachers of biology would welcome a text along these lines. The text under discussion does not fulfill these conditions. It is well written from the college standpoint, but it does not meet the needs of present-day teaching in the high schools. W. W.

The Apple, by Albert E. Wilkinson, Cornell University. Pages xii+492. 15x21 cm. Cloth, 1915. $2.00. Ginn and Company, Boston.

This book is one of the Country Life Education Series published by Ginn and Company. It is beautifully published in every way—paper, illustrations and typography. The author has taken up every phase of orchard culture—the site, adaptation of varieties, orchard heating, planting, pruning, cultivation, fertilizing, drainage, enemies, harvesting and marketing the product. The treatment of the topics is thorough, especially that of insect enemies. Much space is well given to grading and marketing conditions.

For the beginner there is one thing lacking—a discussion of the characteristics and special qualities of varieties of apple. There is a chapter on the adaptation of varieties to the soil, but it covers only a few varieties. There is really no guide to a correct choice of varieties for the new orchard. But the book is good—both to look at, to read, and to study. We can recommend it unreservedly to those interested in apple orcharding. It should certainly be in the school library. W. W.